700 Series Ventilator Systems

Service Manual

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MALLINCKRODT

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Preface

This manual is intended to provide information needed to service the Nellcor Puritan Bennett *700 Series* Ventilator Systems. It is intended for use by certified biomedical engineering technicians or personnel with equivalent experience and training in servicing this type of equipment. The user should complete the Nellcor Puritan Bennett training class geared specifically to the *740* or *760* Ventilator System.

While this manual covers the ventilator configurations currently supported by Nellcor Puritan Bennett, it may not be all-inclusive and may not be applicable to your ventilator. Within the USA, contact Nellcor Puritan Bennett at 1-(800)-635-5267 for questions about the applicability of the information.

Definitions

This manual uses three special indicators to convey information of a specific nature. They include:

Warning

Indicates a condition that can endanger the patient or the ventilator operator.

Caution

Indicates a condition that can damage the equipment.

NOTE:

Indicates points of particular emphasis that make operation of the ventilator more efficient or convenient.

Warnings, cautions, and notes

Please take the time to become familiar with the following, as they cover safety considerations, special handling requirements, and regulations that govern the use of the *700 Series* Ventilator Systems.

Warning

To ensure proper servicing and avoid the possibility of physical injury, only qualified personnel should attempt to service or make authorized modifications to the ventilator.

The user of this product shall have sole responsibility for any ventilator malfunction due to operation or maintenance performed by anyone not trained by Nellcor Puritan Bennett staff.

Warning

To avoid an electrical shock hazard while servicing the ventilator, be sure to remove all power to the ventilator by disconnecting the power source and turning off all ventilator power switches.

Warning

To avoid a fire hazard, keep matches, lighted cigarettes, and all other sources of ignition (e.g., flammable anesthetics and/or heaters) away from the *700 Series* Ventilator System and oxygen hoses.

Do not use oxygen hoses that are worn, frayed, or contaminated by combustible materials such as grease or oils. (Textiles, oils, and other combustibles are easily ignited and burn with great intensity in air enriched with oxygen.)

In case of fire or a burning smell, immediately disconnect the ventilator from the oxygen supply and electrical power source.

Warning

Patients on life-support equipment should be appropriately monitored by competent medical personnel and suitable monitoring devices.

The *700 Series* Ventilator System is not intended to be a comprehensive monitoring device and does not activate alarms for all types of dangerous conditions for patients on life-support equipment.

Warning

An alternative source of ventilation should always be available when using the *700 Series* Ventilator System.

Caution

For a thorough understanding of ventilator operations, be sure to read the *700 Series Ventilator System Operator s Manual* in its entirety before attempting to use the system.

Caution

Before activating any part of the ventilator, be sure to check the equipment for proper operation and, if appropriate, run the self-diagnostic programs described in Section 3.

Caution

Federal law (US) restricts the sale of this device to, or by the order of, any physician.

Caution

Check the ventilator periodically as outlined in the service manual; do not use if defective. Immediately replace parts that are broken, missing, obviously worn, distorted, or contaminated.

Warranty

The *700 Series* Ventilator System is warranted against defects in material and workmanship in accordance with Nellcor Puritan Bennett Medical Equipment Warranty for a period of one year from the time of sale. To ensure the validity of the warranty, be sure to keep a maintenance record.

Year of manufacture

The *700 Series* Ventilator System's year of manufacture is indicated by the fifth and sixth digits of the serial number located at the lower edge of the ventilator front panel.

Manufacturer

Nellcor Puritan Bennett Ireland Ltd.
Mervue, Galway
Ireland

Electromagnetic susceptibility

The *700 Series* Ventilator System complies with the requirements of IEC 601-1-2 (EMC Collateral Standard), including the E-field susceptibility requirements at a level of 10 volts per meter, at frequencies from 26 MHz to 1 GHz, and the ESD requirements of this standard. However, even at this level of device immunity, certain transmitting devices (cellular phones, walkie-talkies, cordless phones, paging transmitters, etc.) emit radio frequencies that could interrupt ventilator operation if located in a range too close to the ventilator. It is difficult to determine when the field strength of these devices becomes excessive. Practitioners should be aware that radio frequency emissions are additive, and that the ventilator must be located a sufficient distance from transmitting devices to avoid interruption. Do not operate the ventilator in a magnetic resonance imaging (MRI) environment. Section 7 describes possible ventilator alarms and what to do if they occur. Consult with your institution's biomedical engineering department in case of interrupted ventilator operation, and before relocating any life support equipment.

Customer assistance

For further assistance contact your local Nellcor Puritan Bennett representative.

Symbols and labels

These symbols and labels appear on the *700 Series* Ventilator System:

I O	**Power switch positions** per IEC 601-1. "I" represents ON position; "O" represents OFF position.
⚠	**Refer to manual** per IEC 601-1. When this symbol appears on product, it means "Refer to documentation for information."
⏚	**Potential equalization point**, per IEC 601-1
− +	External battery connection
⌒	Circuit breaker
SN	Serial number
∿	ac current
🚶	**Type B equipment**, per IEC 601-1
💧 IPX1	Indicates the degree of protection provided by enclosure (drip-proof).
CE 0050	Signifies compliance with the **Medical Device Directive, 93/42/EEC**.
CSA ® NRTL /C	**CSA** and NRTL (Nationally Recognized Testing Laboratory) certification, granted by CSA
TÜV Rheinland Product Safety GS Geprüftes Medizinprodukt Approved medical device Freiwillige Produktprüfung	The **TUV Rheinland** logo signifies TUV Rheinland Type Test approval to Annex III of the Medical Device Directive

Exhaust port connector

⚠ **EXHAUST** ⇩

Inspiratory limb connector

TO
PATIENT ⇩

Expiratory limb connector

FROM
PATIENT ⇧

Oxygen inlet port label

> O_2
>
> ⚠ 40 - 90 psi
> (275 - 620 kPa)
> Use 50 psi (345 kPa)
>
> $\dot{V}_{max}$ = 160 L/min
> (at STPD)

Air intake label

> ⚠ **WARNING:**
> **AIR INTAKE - DO NOT OBSTRUCT. Filter located behind panel. Replace filter every 1,000 running hours or every 3 months, whichever occurs first. Consult operator's manual for complete instructions.**

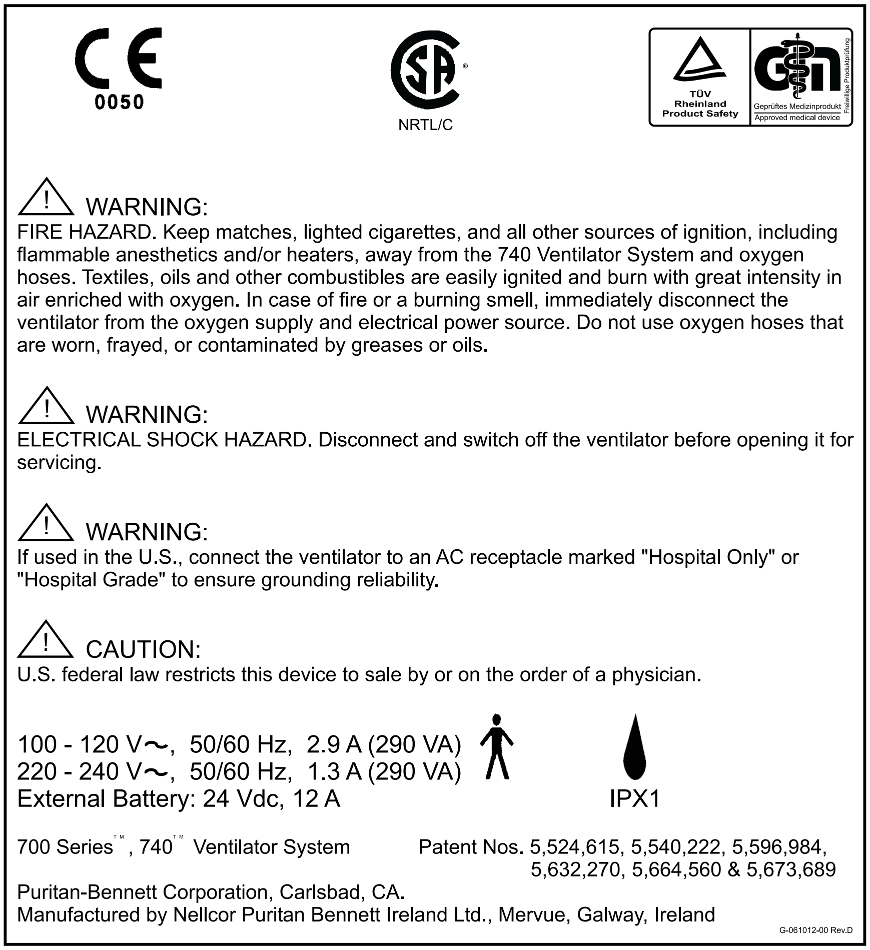
Cooling fan label

> ⚠ **CAUTION:**
> **COOLING FAN- DO NOT OBSTRUCT.**
> **Filter located behind panel. Clean or replace filter as required every 250 running hours or every month, whichever occurs first. Consult operator's manual for complete instructions.**

General life support equipment warning label

> ⚠ **WARNING:**
> **This ventilator is not intended to be a comprehensive monitoring device: some types of dangerous conditions will not activate alarms. Patients on life-support equipment should be appropriately monitored by competent medical personnel and suitable monitoring devices.**
>
> ⚠ **WARNING:**
> **Before use, read operator's manual thoroughly. Before each use, check equipment for proper operation.**

Back panel label (740)



CE 0050

NRTL/C

TÜV Rheinland Product Safety

Geprüftes Medizinprodukt

Approved medical device

Freiwillige Produktprüfung

⚠ WARNING:
FIRE HAZARD. Keep matches, lighted cigarettes, and all other sources of ignition, including flammable anesthetics and/or heaters, away from the 740 Ventilator System and oxygen hoses. Textiles, oils and other combustibles are easily ignited and burn with great intensity in air enriched with oxygen. In case of fire or a burning smell, immediately disconnect the ventilator from the oxygen supply and electrical power source. Do not use oxygen hoses that are worn, frayed, or contaminated by greases or oils.

⚠ WARNING:
ELECTRICAL SHOCK HAZARD. Disconnect and switch off the ventilator before opening it for servicing.

⚠ WARNING:
If used in the U.S., connect the ventilator to an AC receptacle marked "Hospital Only" or "Hospital Grade" to ensure grounding reliability.

⚠ CAUTION:
U.S. federal law restricts this device to sale by or on the order of a physician.

100 - 120 V~, 50/60 Hz, 2.9 A (290 VA)
220 - 240 V~, 50/60 Hz, 1.3 A (290 VA)
External Battery: 24 Vdc, 12 A

IPX1

700 Series™, 740™ Ventilator System

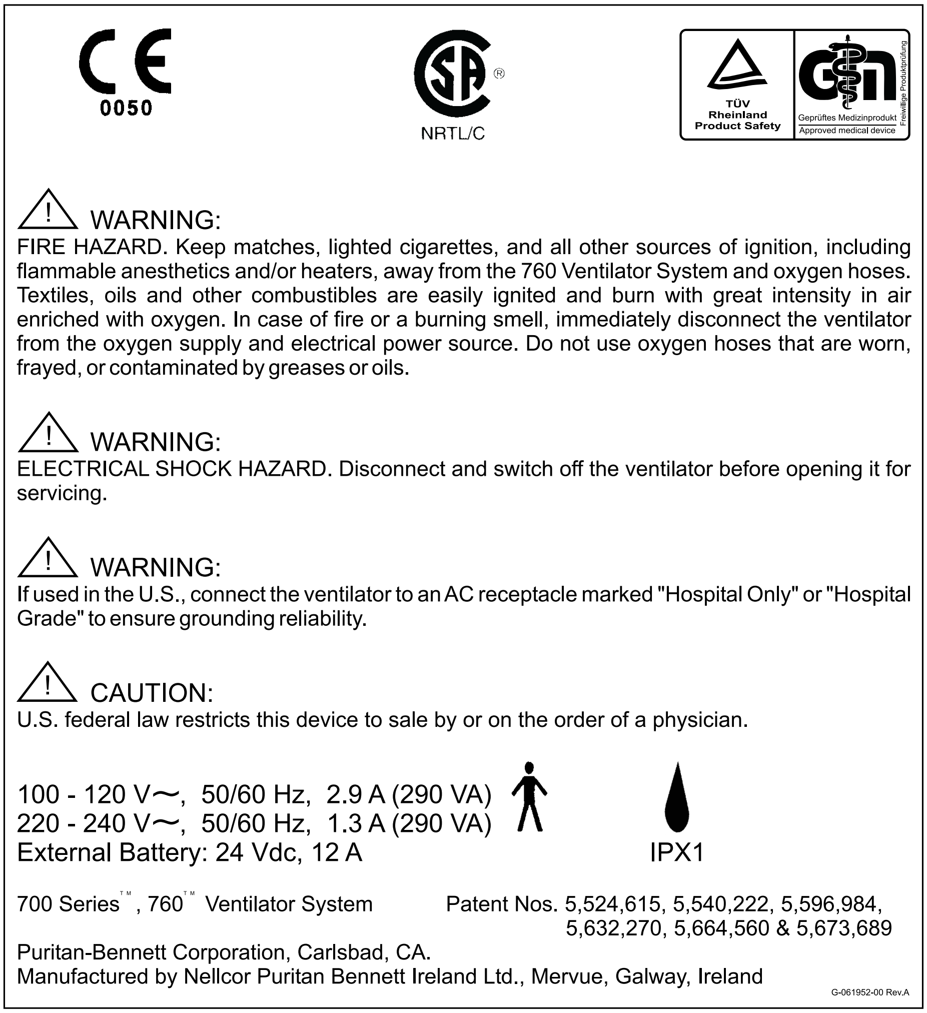
Patent Nos. 5,524,615, 5,540,222, 5,596,984,
5,632,270, 5,664,560 & 5,673,689

Puritan-Bennett Corporation, Carlsbad, CA.
Manufactured by Nellcor Puritan Bennett Ireland Ltd., Mervue, Galway, Ireland

G-061012-00 Rev.D

7-00311

Back panel label (760)



CE 0050

NRTL/C

TÜV Rheinland Product Safety

Geprüftes Medizinprodukt
Approved medical device
Freiwillige Produktprüfung

⚠ WARNING:
FIRE HAZARD. Keep matches, lighted cigarettes, and all other sources of ignition, including flammable anesthetics and/or heaters, away from the 760 Ventilator System and oxygen hoses. Textiles, oils and other combustibles are easily ignited and burn with great intensity in air enriched with oxygen. In case of fire or a burning smell, immediately disconnect the ventilator from the oxygen supply and electrical power source. Do not use oxygen hoses that are worn, frayed, or contaminated by greases or oils.

⚠ WARNING:
ELECTRICAL SHOCK HAZARD. Disconnect and switch off the ventilator before opening it for servicing.

⚠ WARNING:
If used in the U.S., connect the ventilator to an AC receptacle marked "Hospital Only" or "Hospital Grade" to ensure grounding reliability.

⚠ CAUTION:
U.S. federal law restricts this device to sale by or on the order of a physician.

100 - 120 V∼, 50/60 Hz, 2.9 A (290 VA)
220 - 240 V∼, 50/60 Hz, 1.3 A (290 VA)
External Battery: 24 Vdc, 12 A

IPX1

700 Series™, 760™ Ventilator System

Patent Nos. 5,524,615, 5,540,222, 5,596,984,
5,632,270, 5,664,560 & 5,673,689

Puritan-Bennett Corporation, Carlsbad, CA.
Manufactured by Nellcor Puritan Bennett Ireland Ltd., Mervue, Galway, Ireland

G-061952-00 Rev.A

7-00312

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General information

This section provides introductory information on the Nellcor Puritan Bennett *700 Series* Ventilator System. It contains a description of the ventilator, including specifications, required tools and test equipment, schedule of maintenance, and controls and indicators.

1.1 How to use this manual

The *700 Series Ventilator System Service Manual* is intended to be used in conjunction with the *700 Series Ventilator System Operator's Manual*. Both parts are needed for field repair of the ventilator.

In several cases, however, similar information is contained in both manuals:

- Refer to the **"Maintenance"** appendix of the *Operator's Manual* for operator maintenance of filters and the patient system. Refer to the **"Service and repair"** section of the *Service Manual* for maintenance activities performed by the service technician.
- Refer to the **"Self-tests"** section of the *Operator's Manual* or this manual for instructions on running short self-test (SST) and extended self-test (EST). This manual also provides EST troubleshooting information for the qualified service technician.
- The **"Part numbers"** appendix of the *Operator's Manual* contains ordering information for patient system parts. Refer to the **"Parts list"** section of the *Service Manual* for complete part ordering information.

1.2 Safety

Warning

- To prevent personal injury or death, do not attempt any ventilator service while a patient or other person is connected to the ventilator.
- To prevent disease transmission, use personal protective equipment when handling contaminated bacterial filters or other patient accessories. Use Cavicide to kill bloodborne pathogens, as required.

Ventilator maintenance may involve exposure to hazardous materials, equipment, and conditions such as: possible electrical shock; pressurized gas; transmittable diseases; and fire, which could result from an oxygen-enriched environment and easily ignitable material. Before servicing the *700 Series* Ventilator System, be aware of possible hazards and necessary precautions to be taken.

- **Familiarize yourself with the warnings and cautions on the ventilator labels and in related publications, including this manual.** Also familiarize yourself with any warnings and cautions associated with the service equipment and materials being used, as well as those posted in the facility where the ventilator is serviced.

- Use any applicable personal protective equipment and adhere to the applicable warnings and cautions.
- **Be aware of the safety standards and considerations specific to your situation.** Safety standards may vary with international, federal, state, and local regulatory agencies. When in doubt, consult material safety data sheets; environmental, health, and safety professionals; and regulatory affairs specialists. In addition, many facilities and institutions may have their own special safety considerations.
- **Be sure the ventilator passes the performance verification (Section 5) before it is returned to operation after being serviced.** The performance verification ensures the product's safety in addition to its functional integrity.

1.3 General description

The *700 Series* Ventilator System (including the *740* and *760* Ventilators) provides respiratory support for a wide range of pediatric to adult patients for a wide variety of clinical conditions. The ventilator's mixing technique allows it to ventilate critically ill patients at adjustable oxygen concentrations without the need for a blender, compressor, or hospital-grade wall air.

The *700 Series* Ventilator System can be mains or battery powered. Each ventilator includes two microcontrollers: one for breath delivery (which controls ventilation), and one for the user interface (which monitors ventilator and patient data). Each microcontroller verifies that the other is functioning properly. Using two independent microcontrollers in this fashion prevents a single fault from causing a simultaneous failure of controlling and monitoring functions.

The *700 Series* Ventilator System supplies mandatory or spontaneous breaths with a piston-based pneumatic system. Mandatory breaths can be *volume control ventilation* (VCV, available on *740* and *760* Ventilators) or *pressure control ventilation* (PCV, available on the *760* Ventilator only). VCV delivers breaths to the patient at a preset tidal volume, peak flow, waveform, and oxygen concentration at a minimum respiratory rate. PCV delivers breaths to the patient at a preset inspiratory pressure, I:E ratio or inspiratory time, rise time factor (how quickly inspiratory pressure rises to achieve the set inspiratory pressure), and oxygen concentration at a minimum respiratory rate. A spontaneous breath allows the patient inspiratory flows of up to 300 L/min, with or without *pressure support ventilation* (PSV). On the *760* Ventilator, you can set the rise time factor and exhalation flow sensitivity (that is, the point at which the ventilator cycles from inspiration to exhalation) in PSV.

The ventilator begins *apnea ventilation* if no patient- or operator-initiated breath is delivered within the operator-selected apnea interval. Apnea ventilation is available in all modes (for ventilators equipped with software Rev. J or later). On the *740* Ventilator, only VCV breaths are available in apnea ventilation. On the *760* Ventilator, VCV or PCV breaths are available in apnea ventilation.

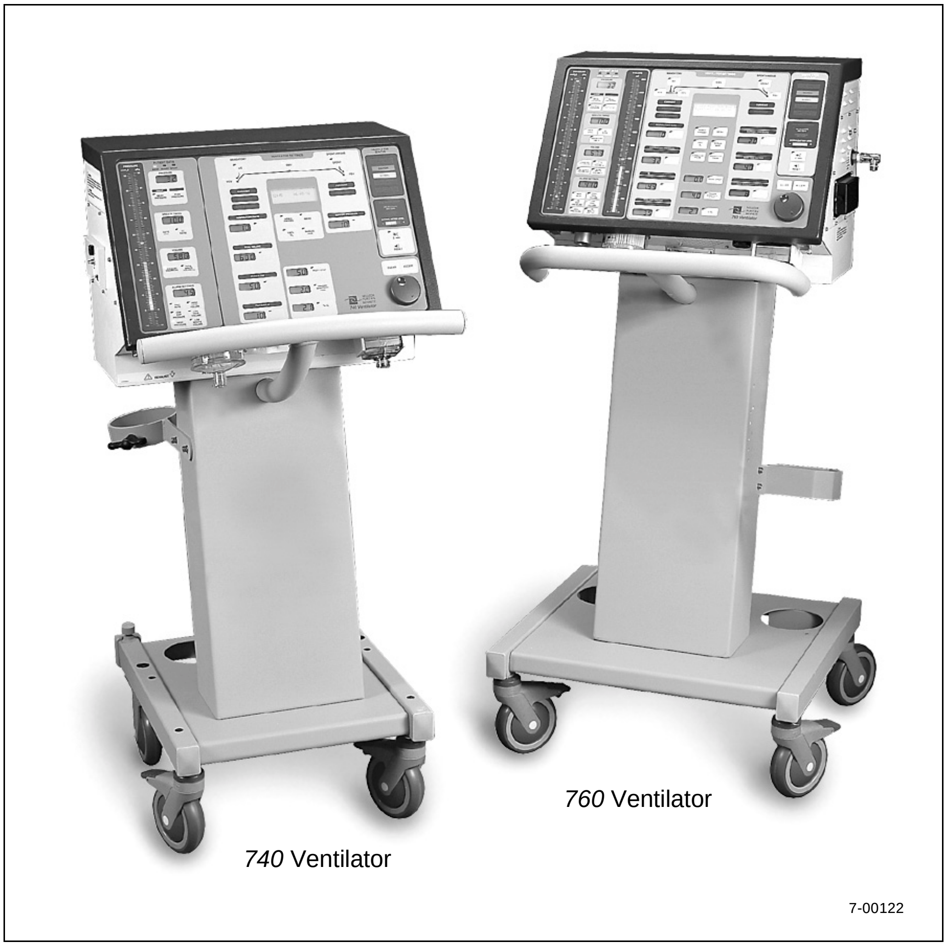

760 Ventilator
740 Ventilator
7-00122

Figure 1-1. ***700 Series*** **Ventilator Systems**

1.4 Configuration information

The *700 Series* Ventilator System is available in a variety of versions, intended to meet differing needs and regulations throughout the world. The major differences in configuration among ventilators are listed below:

- **Language.** Keyboard (user interface) and other ventilator labeling available in assorted languages.
- **Electrical requirements.** Available in 110 V and 230 V.
- **Power cord.** A variety of plug ends available.
- **Oxygen fitting and hose.** Available in DISS (diameter index safety standard) male and female, NIST (non-interchangeable screw thread), Australian type, Air Liquide, and Dräger.
- **Mounting.** Cart or shelf mount available.
- **Accessories.** Ventilators may have the accessories listed in Section 1.5.

1.5 Accessories

The following accessories are either required or can be used with the ventilator.

Ventilator breathing circuit. A variety of reusable Nellcor Puritan Bennett circuits, adult and pediatric, with and without water traps, and with and without heated wire, is available. Contact your Nellcor Puritan Bennett representative. In addition, other breathing circuits may be used with the ventilator, provided they ensure that the ventilator breathing system meets the specifications stated in Table 1-1 (see *Results of ventilator breathing system testing*).

Humidification device. The *700 Series* Ventilator supports use of an optional humidification device, including a heated humidifier, heat and moisture exchanger (HME), or heated wire. A Fisher & Paykel MR730 Humidifier is available for the ventilator. Mounting brackets are available for the Fisher & Paykel humidifiers and the Hudson RCI ConchaTherm Humidifier.

1.6 Specifications

Ventilator specifications are listed in Table 1-1.

Table 1-1: Specifications

Physical characteristics	
Weight	Ventilator only: 30 kg (66 lb) Cart only: 18 kg (40 lb) External battery: 12.75 kg (28 lb)
Dimensions	Ventilator only: 378 mm high x 515 mm wide x 370 mm deep (14.9 in. high x 20.3 in. wide x in. 14.6 in. deep) Ventilator and cart: 1255 mm high x 515 mm wide x 370 mm deep (49.4 in. high x 20.3 in. wide x 14.6 in. deep)
Environmental requirements	
Temperature	Operating: 5 to 45°C (41 to 113°F) at 10 to 95% relative humidity Storage: -40 to 60°C (-40 to 140°F) at 10 to 95% relative humidity
Atmospheric pressure	Operating: 8.7 to 16.0 psi (600 to 1100 hPa) Storage: 7.3 to 16.0 psi (500 to 1100 hPa)

Table 1-1: Specifications (continued)

Altitude	Operating: Up to 4570 m (15,000 ft) Storage: Up to 15,240 m (50,000 ft)
Storage	Maintain under conditions listed above. Remove batteries from ventilator before storage. See “Electrical specifications, Battery shelf life when charge is not maintained” for battery life details.
Pneumatic specifications	
Oxygen inlet supply	Pressure: 40 to 90 psi (275 to 620 kPa) Flow: Maximum of 160 L/min at standard temperature and pressure, dry (STPD) Fitting type: DISS male, DISS female, NIST, Air Liquide, Australian type, or Dräger (depending on country and configuration) Oxygen regulator bleed: Up to 3 L/min **Warning** Due to excessive restriction of the Air Liquide, Australian, and Dräger hose assemblies, reduced FIO_2 levels may result when oxygen inlet pressures < 50 psi (345 kPa) are employed. Make sure oxygen inlet pressure is ≥ 50 psi (345 kPa) when using these hose assemblies, to maintain correct FIO_2 levels.
Connectors	Inspiratory limb connector: ISO 22-mm conical male Expiratory limb connector: ISO 22-mm conical female Gas exhaust port: ISO 30-mm conical
Gas mixing system	Range of delivery to the patient: Up to 300 L/min for pressure support ventilation (PSV) spontaneous breaths or pressure control ventilation (PCV) mandatory breaths; 3 to 150 L/min for mandatory or assisted volume control ventilation (VCV) breaths. Leakage from one gas system to another: Not applicable (no high-pressure air source) Design pressure: 50 psi (345 kPa) Operating pressure range: 40 to 90 psi (275 to 620 kPa)
Maximum limited pressure	92 cmH_2O (92 hPa) A dedicated backup circuit opens the safety valve if system pressure exceeds 115 cmH_2O (113 hPa).
Maximum ventilating pressure	89 cmH_2O (89 hPa) for VCV breaths or 80 cmH_2O (80 hPa) for PSV breaths and PCV breaths (including PEEP), ensured by HIGH PRESSURE limit.

Table 1-1: Specifications (continued)

Results of ventilator breathing system testing (using circuits identified for use with *700 Series* Ventilator)	Resistance ranges: Adult circuits: Inspiratory resistance at 60 L/min: 4.8 to 5.7 cmH_2O (ventilator powered off), 2.0 cmH_2O maximum at 0 cmH_2O CPAP. Expiratory resistance at 60 L/min: 1.6 to 2.2 cmH_2O (ventilator powered off), 4.6 cmH_2O maximum at 0 cmH_2O CPAP. Pediatric circuits: Inspiratory resistance at 30 L/min: 1.7 to 3.0 cmH_2O (ventilator powered off), 2.8 cmH_2O maximum at 0 cmH_2O CPAP. Expiratory resistance at 30 L/min: 0.8 to 1.0 cmH_2O (ventilator powered off), 2.7 cmH_2O maximum at 0 cmH_2O CPAP. NOTE: The circuits identified for use with the *700 Series* Ventilator ensure that the ventilator breathing system does not exceed the EN 794-1 values for maximum resistance (both inspiratory and expiratory), which are as follows: Adult: 60 L/min, 6 hPa (6 cmH_2O); Pediatric: 30 L/min, 6 hPa (6 cmH_2O). Compliance range of recommended breathing circuits: 2.40 to 3.33 ml/cmH_2O Internal volume: Not applicable. The *700 Series* Ventilator automatically adjusts for volume losses due to gas compressibility (that is, automatic compliance compensation), subject to a maximum delivered volume of 2.5 L. NOTE: • To ensure that compliance compensation functions correctly, the user must run SST or EST with the circuit configured as intended for use on the patient. • Ventilator breathing circuit testing specifications are based on the recommended configurations shown in the *Operator's Manual.* .
Electrical specifications	
Power supply	Input range: 100 to 120 V ac nominal (110 V units), 220 to 240 V ac nominal (230 V units), 50/60 Hz, 2.9 A (110 V units) or 1.3 A (230 V units), 290 VA Mains fuse: 10 A, 250 V, medium time lag, high (H) breaking capacity, 6 x 32 mm (meets IEC and CSA standards). (A circuit breaker in the power assembly opens when current draw exceeds 4 A.)
Earth leakage current	At 100 to 120 V ac operation: less than 300 µA At 220 to 240 V ac operation: less than 500 µA (Includes ventilator, power cord, and internal and external batteries)
Enclosure leakage current	Less than 50 µA in normal condition (all units) Less than 300 µA in single fault condition at 100-120 V AC operation Less than 500 µA in single fault condition at 220-240 V AC operation
Ground resistance	< 0.1 Ω (excluding power cord); < 0.2 Ω (including power cord)

Table 1-1: Specifications (continued)

Internal battery	24 V dc, 7 Ah Operating time (for a new, fully charged battery at 20°C and sea level): • Approximately 2.5 hours under nominal conditions (nominal conditions: tidal volume 0.6 L, respiratory rate 15/min, PEEP/CPAP 5 cmH_2O, peak flow 60 L/min, plateau 0 s; average peak pressure 30 cmH_2O, average mean pressure 8 cmH_2O) • Approximately 2 hours under extreme conditions (extreme conditions: tidal volume 1.2 L, respiratory rate 15/min, PEEP/CPAP 15 cmH_2O, peak flow 60 L/min, plateau 0 s; average peak pressure 64 cmH_2O, average mean pressure 24 cmH_2O) Recharge time: 2.5 to 3 hours in ventilator Charges automatically while ventilator is connected to ac power and power switch is on (including standby mode) Charge level indicated on user interface
External battery	24 V dc, 17 Ah Operating time (for a new, fully charged battery at 20°C and sea level): • Approximately 7 hours under nominal conditions (See internal battery for definition of nominal conditions.) • Approximately 5.5 hours under extreme conditions (See internal battery for definition of extreme conditions.) Recharge time: 7.5 to 8 hours in ventilator (3 to 4 hours using optional battery charger) Charges automatically while ventilator is connected to ac power and the power switch is on (including standby mode) Battery charge levels available under Battery info menu function
Battery shelf life when charge is not maintained	Ideally internal and external batteries should be stored in a cool, dry place. If the batteries are stored *without* maintaining charge, typical shelf life is as follows: • At 0 to 20°C (32 to 68°F): 12 months • At 21 to 30°C (69 to 86°F): 9 months • At 31 to 40°C (87 to 104°F): 5 months • At 41 to 50°C (105 to 122°F): 2.5 months NOTE: • If you plan to store the ventilator for longer than 6 months, remove batteries before storage. Replace the batteries before using the ventilator again. • Battery life specifications are approximate. To ensure maximum battery life, maintain full charge and minimize the number of complete discharges.
Serial communications	DB9 male connector Lets computer access ventilator data. Used to upload/download service data and to perform other communications functions.
Alarm volume	Minimum (level 1): 74 dBA at 1 m Maximum (level 5): 88 dBA at 1 m
Measuring and display devices	
Mean airway pressure	Sensing position: Exhalation limb Range: 0 to 99 cmH_2O (0 to 99 hPa) Type: Silicon solid state
Peak pressure	Sensing position: Exhalation limb Range: 0 to 140 cmH_2O (0 to 140 hPa) Type: Silicon solid state

Table 1-1: Specifications (continued)

Plateau pressure (*760* Ventilator only)	Sensing position: Exhalation limb Range: 0 to 140 cmH$_2$O (0 to 140 hPa) Type: Silicon solid state
PEEP/CPAP pressure (*760* Ventilator only)	Sensing position: Exhalation limb Range: 0 to 140 cmH$_2$O (0 to 140 hPa) Type: Silicon solid state
Rate	Sensing position: Microprocessor Range: 1 to 500 breaths/min Type: Calculated from inspiratory and expiratory time measurements
I:E ratio	Sensing position: Microprocessor Range: 1:99.9 to 9.9:1 Type: Calculated from inspiratory and expiratory time measurements
Inspiratory time (*760* Ventilator only)	Sensing position: Microprocessor Range: 0.1 to 9.9 s Type: Inspiratory time measurement
Exhaled tidal volume	Sensing position: Exhalation limb Range: 0 to 9 L Type: Differential pressure pneumotach
Total minute volume	Sensing position: Exhalation limb Range: 0 to 99 L Type: Differential pressure pneumotach
Delivered volume (*760* Ventilator only)	Sensing position: Exhalation limb Range: 0 to 3000 ml Type: Differential pressure pneumotach
Spontaneous minute volume (*760* Ventilator only)	Sensing position: Exhalation limb Range: 0 to 99 L Type: Calculated from expiratory flow measurements
FIO$_2$ sensor	Sensing position: Inspiration manifold Range: 18 to 109 % Type: Galvanic cell Sensor life: 2 years, nominal. (Actual life depends on operating environment; operation at higher temperature or FIO$_2$ levels will result in shorter sensor life.) NOTE: To achieve compliance with the more rigid requirements for oxygen monitoring (as set forth in ISO 7767), Nellcor Puritan Bennett recommends using an external monitor that meets that standard.
Service specifications	
Self-test capabilities	Automatic power-on self-test (POST): Verifies integrity of electronics. Short self-test (SST): An abbreviated version of EST to be run by the operator. Characterizes system leaks and system/tubing compliance. Extended self-test (EST): Lets the technician thoroughly test the operational integrity of the ventilator, both electronics and pneumatics. Tests can also be run individually, in diagnostic EST mode. Automatic, ongoing software and hardware checks.
Bacteria filter efficiency	Inspiratory and expiratory filters (disposable and reusable): 99.97% retention of 0.3 µm particles at 100 L/min.
Languages	Software and user labeling available in Dutch, English, French, German, Italian, Japanese, Polish, Portuguese, Russian, or Spanish.

Table 1-1: Specifications (continued)

Other built-in service capabilities	Serial port enabling (for file transfer); loopback test for Communications option serial ports; battery load test; calibration of oxygen sensor, oxygen regulator pressure transducer, and PEEP pump; equalization of exhalation pressure transducer/cylinder pressure transducer (P_e/P_{cyl}), input and viewing of calibration constants; resetting of preventive maintenance hours; review and erasing of diagnostic code logs; review of EST test status; and real-time display of monitored ventilator parameters.
Compliance and approvals	
CE 0050	The *700 Series* Ventilator System complies with the requirements of Directive 93/42/EEC concerning medical devices. It therefore bears the CE marking.
IEC 601-1 classification	Protection class I, Type B, internally powered, drip-proof equipment, continuous operation.
The *700 Series* Ventilator System complies with these International and European standards:	IEC 601-1/EN 60601-1 IEC 601-1-2/EN 60601-1-2 EN 794-1 In addition, the *700 Series* Ventilator System has been approved to the type test requirements of Annex III of the Medical Device Directive, by the notified body, TUV Rheinland.
The *700 Series* Ventilator System has been certified by these test agencies:	TUV Rheinland: EC Type Test Certificate to the requirements of Annex III of the Medical Device Directive. CSA: CSA C22.2 No. 601-1, CSA C22.2 No. 601-2-12, NRTL certification.

1.7 Tools, Equipment, and Service Materials

Caution

Always use metric tools to remove metric fasteners. Using nonmetric tools to remove metric fasteners can damage fasteners.

The tools, equipment, and service materials listed in Table 1-2 are used to service the *700 Series* Ventilator. A kit of *700 Series* Ventilator service tools (P/N G-061561-00) is available; its contents are indicated in Table 1-2.

Table 1-2: Tools, equipment, and service materials

Description	Manufacturer and model or Nellcor Puritan Bennett part number	Where used
Service tool kit (Includes parts in this table marked with an asterisk [*])	G-061561-00	Various service procedures
Hex drivers, 1.5-mm, 2.5-mm, 3-mm, 4-mm, and 5-mm	Local supplier	Various service procedures
Hex driver, 1/16-in.	Local supplier	Knob set screw
Hex driver, 7/64-in.	Local supplier	Autozero solenoid retaining screws

*Parts marked with an asterisk are included in the *700 Series* Ventilator service tool kit (P/N G-061561-00). This kit includes 10 of the antistatic label (P/N G-061660-00), but 1 of every other item.

Table 1-2: Tools, equipment, and service materials (continued)

Description	Manufacturer and model or Nellcor Puritan Bennett part number	Where used
Nutdrivers or wrenches, 5-mm, 5.5-mm (or 7/32-in.), 7-mm, 8-mm, and 11-mm	Local supplier	Various service procedures
Wrench, open-ended (or adjustable)	Local supplier	
• 10-mm		• Inspiration manifold thermistor (previous version), nurse call connector lock nut (Communications option assembly)
• 14-mm		• Nebulizer connector lock nut (Communications option assembly)
• 19-mm		• Inspiration manifold thermistor (current version), oxygen regulator pressure transducer; oxygen regulator nut, remote alarm connector lock nut (Communications option assembly)
• 3/16-in.		• Oxygen regulator adjustment screw • Serial (RS-232) port hardware (Communications option assembly)
• 3/8-in.		• Oxygen regulator nut
POZIDRIV® screwdrivers, no. 0, 1, and 2	Local supplier	Various service procedures
Flat-bladed screwdriver	Local supplier	Various service procedures
Flat-bladed screwdriver with long (>20-cm) shank	Local supplier	Piston/cylinder assembly retaining screws

NOTE:

Use POZIDRIV screwdrivers only to remove POZIDRIV screws. Using Phillips-head screwdrivers on POZIDRIV heads may damage the screw heads.

[*] Parts marked with an asterisk are included in the *700 Series* Ventilator service tool kit (P/N G-061561-00). This kit includes 10 of the antistatic label (P/N G-061660-00), but 1 of every other item.

Table 1-2: Tools, equipment, and service materials (continued)

Description	Manufacturer and model or Nellcor Puritan Bennett part number	Where used
Phillips screwdriver, no. 1	Local supplier	Cart
NOTE: Use Phillips screwdrivers only to remove Phillips-head screws. Using POZIDRIV screwdrivers on Phillips heads may damage the screw heads.		
NVRAM extractor tool*	G-061566-00 or local supplier	Removing NVRAM on controller PCB
EPROM extractor tool, 32-pin, PLCC type*	G-061914-00 or local supplier	Removing software EPROMs
Drill with 1/8-in. (3-mm) bit	Local supplier	Removing serial number plate
Electrical safety analyzer, capable of measuring ground resistance and leakage current	BIO-TEK Model 601 PRO, from: BIO-TEK Instruments, Inc., Highland Park, Box 998, Winooski, VT 05404-0998 USA, 1-800-451-5172; or equivalent	Electrical safety test
Digital multimeter (DMM) accurate to 3 decimal places	Local supplier	Performance verification
Multimeter patch cord set, 0.025 square receptacle (Includes red cord (P/N G-061579-00) and black cord (P/N G-061580-00))*	G-061567-00 or equivalent	Performance verification
Pneumatic calibration analyzer or equivalent devices capable of measuring oxygen percent, flow, BTPS volume, pressure, and barometric pressure. Oxygen analyzer connector tee. Required accuracies: • Flow: 2.75% of reading ±0.05 slpm • Volume: 2% of reading or ±1 digit • Low pressure (-150 to +150 cmH$_2$O): 0.75% of reading ±0.04 cmH$_2$O • High pressure (0 to 150 psig): 1.0% of reading ±0.1 psi • Oxygen percentage: ±2% oxygen	Nellcor Puritan Bennett *PTS 2000* Performance Test System (4-076185-00) or Timeter RT-200 Calibration Analyzer (from: Allied Healthcare Products, Inc., 1720 Sublette Ave., St. Louis, MO 63110, 1-800-444-3940). NOTE: If the RT-200 is used , a separate oxygen analyzer (with coupling tee) is also required.	Performance verification, EST, oxygen regulator pressure transducer calibration
ESD-safe vacuum cleaner with 0.2 µm filter (rated for photocopiers and laser printers)	Local supplier	General cleaning of ventilator interior
*Parts marked with an asterisk are included in the *700 Series* Ventilator service tool kit (P/N G-061561-00). This kit includes 10 of the antistatic label (P/N G-061660-00), but 1 of every other item.		

Table 1-2: Tools, equipment, and service materials (continued)

<table>
<tr><th>Description</th><th>Manufacturer and model or Nellcor Puritan Bennett part number</th><th>Where used</th></tr>
<tr><td>Static-dissipative field service kit (includes wrist strap, static-dissipative mat, and ground cord)*</td><td>G-061661-00 or equivalent</td><td>Various service procedures</td></tr>
<tr><td>Oxygen source, 40 to 90 psi (275 to 620 kPa); (≥50 psi (345 kPa) required for oxygen sensor calibration check)</td><td>Local supplier</td><td>EST, performance verification, oxygen sensor calibration check</td></tr>
<tr><td colspan="3">Warning
Due to excessive restriction of the Air Liquide, Australian, and Dräger hose assemblies, reduced FIO_2 levels may result when oxygen inlet pressures < 50 psi (345 kPa) are employed. Make sure oxygen inlet pressure is ≥ 50 psi (345 kPa) when using these hose assemblies, to maintain correct FIO_2 levels.</td></tr>
<tr><td>Stopper, wye (no. 2)*</td><td>G-061574-00 or local supplier</td><td>SST, EST, performance verification</td></tr>
<tr><td>Stopper, inspiration port (no. 3)*</td><td>G-061575-00 or local supplier</td><td>EST, performance verification, battery load test</td></tr>
<tr><td rowspan="2">Ventilator breathing circuit, adult, reusable, without heated wire (to use as test circuit)*</td><td>G-061208-00 or equivalent</td><td>EST, performance verification</td></tr>
<tr><td colspan="2">NOTE:
To ensure that compliance compensation functions correctly, the user must run EST or SST with the circuit configured as intended for use on the patient.</td></tr>
<tr><td>Tubing kit, performance verification (Includes two couplings (P/N 4-003443-00), tube junction connector (P/N 4-011521-00) (quantity of 2), and 30-cm, 3/16-in. ID x 3/8-in. OD tubing)*</td><td>G-061573-00</td><td>Performance verification</td></tr>
<tr><td>Test lung with strap*</td><td>4-000612-00</td><td>Performance verification</td></tr>
<tr><td>PEEP pump calibration tool*</td><td>G-061540-00</td><td>Calibrating PEEP pump</td></tr>
<tr><td>P_eP_{cyl} gain equalization kit (Includes 5-ml syringe (P/N G-061558-00), reservoir (P/N 4-011413-00), tee (4-003891-00), and four 25-cm lengths, 3-mm ID x 6-mm OD tubing)*</td><td>G-061557-00</td><td>P_eP_{cyl} gain equalization</td></tr>
<tr><td>Oxygen regulator pressure transducer (P_o) calibration tool</td><td>For use with:
• <i>PTS 2000</i>: 4-079050-00
• <i>RT-200</i>: G-061541-00</td><td>Calibrating oxygen regulator pressure transducer</td></tr>
<tr><td colspan="3">*Parts marked with an asterisk are included in the <i>700 Series</i> Ventilator service tool kit (P/N G-061561-00). This kit includes 10 of the antistatic label (P/N G-061660-00), but 1 of every other item.</td></tr>
</table>

Table 1-2: Tools, equipment, and service materials (continued)

Description	Manufacturer and model or Nellcor Puritan Bennett part number	Where used
Cable ties, small	G-061096-00 or local supplier	Various places
Cutting tool	Local supplier	Various service procedures (for cutting cable ties or wires)
PTFE tape*	G-060759-00	Installing oxygen regulator pressure transducer, oxygen fitting, and oxygen adapters
Grease, 10 gram*	G-060532-00	Greasing rack
Leak test fluid	4-004489-00	O_2 adapter assembly
Rivets	G-061182-00	Attaching serial number plate
Isopropyl alcohol	Local supplier	General cleaning
Cleaning spray, UI*	G-061576-00	Cleaning keyboard
Cotton swabs	Local supplier	General cleaning
Brush, rack grease*	G-061568-00	Greasing rack
Touch-up paint		
• White liquid laquer	• G-061999-00	• Ventilator cabinet
• Charcoal liquid laquer	• G-062000-00	• Ventilator lid
• Gray liquid laquer	• G-061361-00	• Ventilator cart
Electrostatic-shielding bags		
• 66 x 46 cm (26 x 18 in.)*	• G-061534-00	• UI display PCB
• 13 x 20 cm (5 x 8 in.)*	• G-061532-00	• Optoswitch
• 28 x 38 cm (11 x 15 in.)*	• G-061533-00	• Controller PCB, BBU PCB, pressure solenoid PCB

*Parts marked with an asterisk are included in the *700 Series* Ventilator service tool kit (P/N G-061561-00). This kit includes 10 of the antistatic label (P/N G-061660-00), but 1 of every other item.

1.8 Periodic maintenance

Table 1-3 lists the periodic maintenance activities (other than patient system maintenance) required for the *700 Series* Ventilator. The hours remaining until service is due are displayed when POST is run and through the *Service summary* menu option (see the *Operator's Manual*). For patient system maintenance, consult the *Operator's Manual*.

Table 1-3: Schedule of periodic maintenance

Interval	Part	Activity
250 hours or 1 month of use (or more often, if required)	Main fan filter (G-060531-00)	Either vacuum filter or wash filter in a warm detergent solution, rinse, and dry well. Replace filter when it shows signs of wear or when a FAN FAILED ALERT alarm occurs.
1000 hours or 3 months of use (or more often, if required)	Air intake filter (G-060457-00)	Replace at recommended interval or when an AIR INTAKE BLOCKED alarm occurs.
Every year or per your hospital's protocol	Entire ventilator	Electrical safety test
15,000 hours of operation	Entire ventilator	Install 15,000-hour preventive maintenance kit (P/N G-061166-00), including performance verification.
30,000 hours of operation	Entire ventilator	Install 30,000-hour preventive maintenance kit (P/N G-061167-00), including performance verification.
Every 2 years or as necessary	• Internal battery (G-061139-00) • External battery (G-061140-00) • Oxygen sensor (G-062010-00 for sensor only; G-062009-00 if replacing a sensor with integral harness), NOTE: Using ventilator menu functions, you can view the remaining estimated life of the internal and external batteries, in hours.	Replace.

1.9 Service kits

Table 1-4 lists the *700 Series* Ventilator service kits. Section 9 lists the mounting kits available for the ventilator.

Table 1-4: Service kits

Part no.	Description
G-061166-00	15,000-hour preventive maintenance kit. See Section 9 for contents.
G-061167-00	30,000-hour preventive maintenance kit. See Section 9 for contents.
G-061561-00	*700 Series* Ventilator service tool kit. See Table 1-2 for contents.
G-061560-00	*700 Series* Ventilator spare parts kit. See Section 9 for contents.
G-060872-00	*700 Series* Ventilator return (repackaging) kit.

1.10 Controls and indicators

Operating the ventilator involves setting the controls and observing indicators on the ventilator keyboard. For further details, see Figure 1-2, Figure 1-3, and Table 1-5 through Table 1-7. The keyboard is grouped into three sections:

- VENTILATOR SETTINGS: Where breath delivery variables are set.
- PATIENT DATA: Where alarm limits are set, and monitored pressures, breath timing, and volumes may be viewed.
- VENTILATOR STATUS: Where alarm status and operating condition of the ventilator are viewed.

Caution

To avoid damaging the keyboard, do not puncture it with sharp objects.

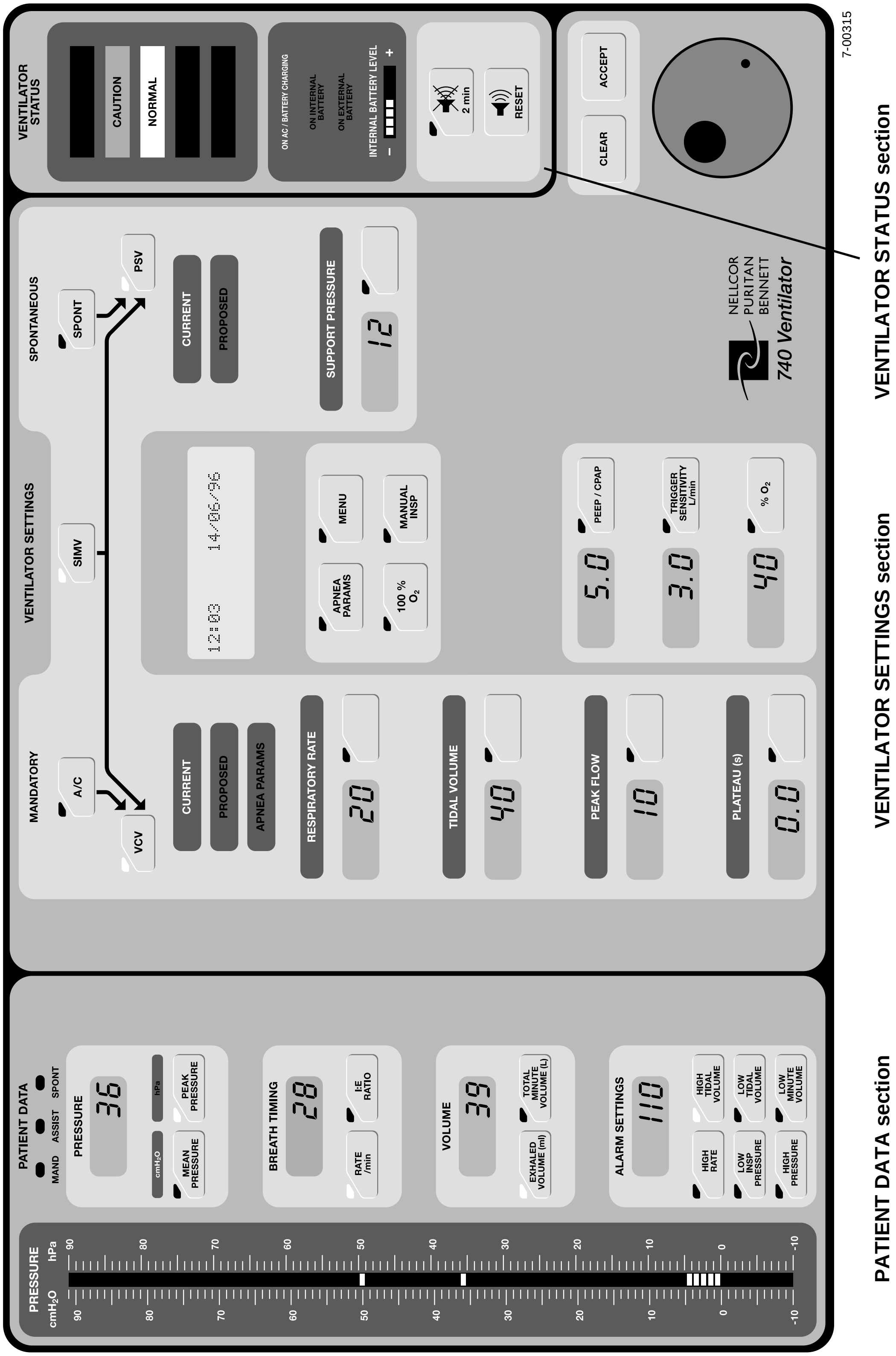

VENTILATOR STATUS
CAUTION
NORMAL
ON AC / BATTERY CHARGING
ON INTERNAL BATTERY
ON EXTERNAL BATTERY
INTERNAL BATTERY LEVEL
–
+
2 min
RESET
ACCEPT
CLEAR
7-00315
VENTILATOR STATUS section
SPONTANEOUS
SPONT
PSV
CURRENT
PROPOSED
SUPPORT PRESSURE
12
NELLCOR PURITAN BENNETT
740 Ventilator
VENTILATOR SETTINGS
SIMV
12:03
14/06/96
MENU
MANUAL INSP
APNEA PARAMS
100 % O2
PEEP / CPAP
TRIGGER SENSITIVITY L/min
% O2
5.0
3.0
40
VENTILATOR SETTINGS section
MANDATORY
A/C
VCV
CURRENT
PROPOSED
APNEA PARAMS
RESPIRATORY RATE
20
TIDAL VOLUME
40
PEAK FLOW
10
PLATEAU (s)
0.0
PATIENT DATA
MAND
ASSIST
SPONT
PRESSURE
36
cmH2O
hPa
MEAN PRESSURE
PEAK PRESSURE
BREATH TIMING
28
RATE /min
I:E RATIO
VOLUME
39
EXHALED VOLUME (ml)
TOTAL MINUTE VOLUME (L)
ALARM SETTINGS
110
HIGH RATE
HIGH TIDAL VOLUME
LOW INSP PRESSURE
LOW TIDAL VOLUME
HIGH PRESSURE
LOW MINUTE VOLUME
PRESSURE
cmH2O
hPa
90
80
70
60
50
40
30
20
10
0
-10
PATIENT DATA section

Figure 1-2. Controls and indicators on *740* Ventilator keyboard

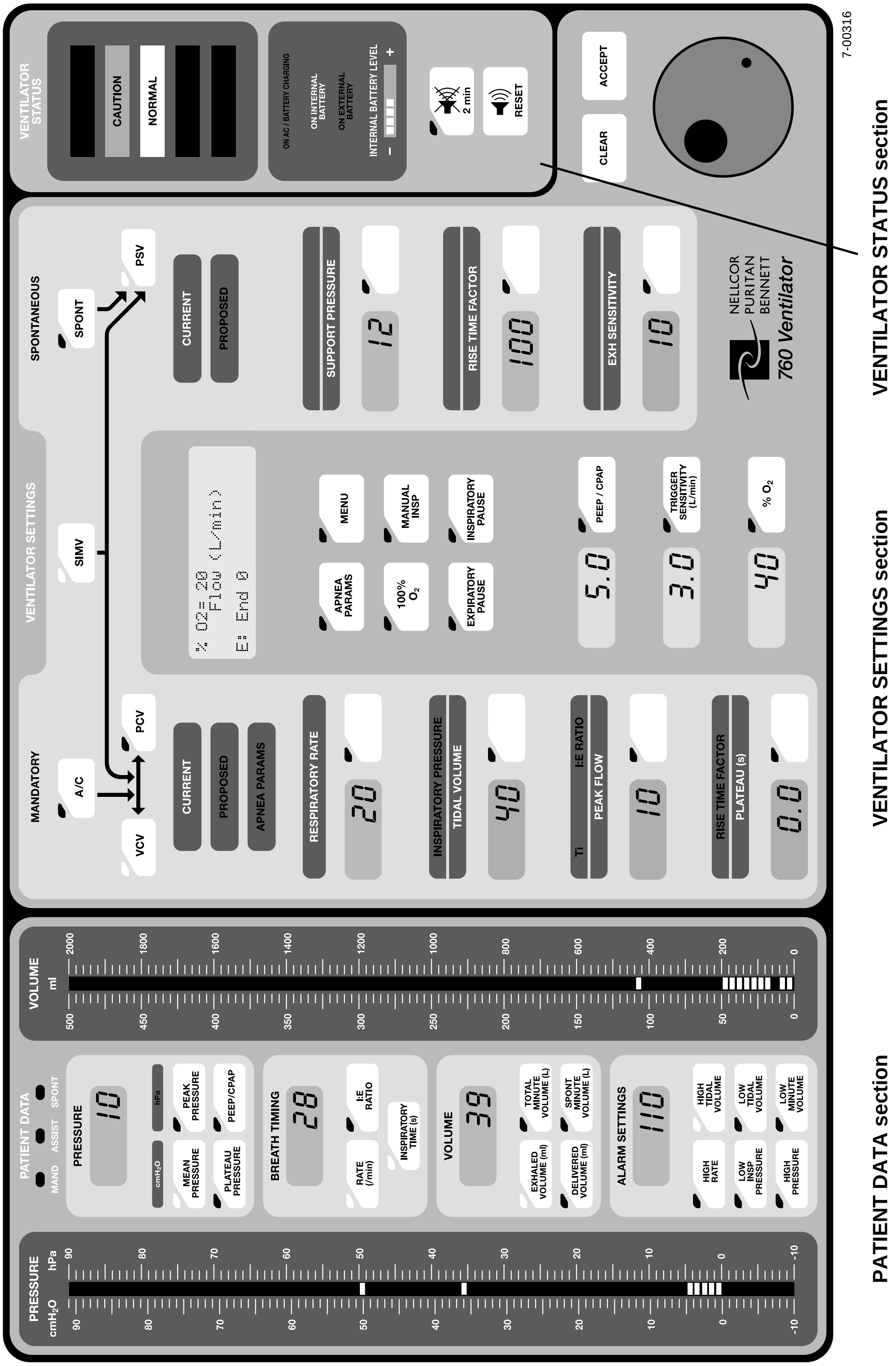

7-00316
VENTILATOR STATUS
CAUTION
NORMAL
ON AC / BATTERY CHARGING
ON INTERNAL BATTERY
ON EXTERNAL BATTERY
INTERNAL BATTERY LEVEL
– +
2 min
RESET
ACCEPT
CLEAR
VENTILATOR SETTINGS
SPONTANEOUS
SPONT
PSV
SIMV
MANDATORY
A/C
PCV
VCV
CURRENT
PROPOSED
APNEA PARAMS
SUPPORT PRESSURE
12
RISE TIME FACTOR
100
EXH SENSITIVITY
10
NELLCOR PURITAN BENNETT
760 Ventilator
% O2= 20
Flow (L/min)
E: End 0
MENU
MANUAL INSP
INSPIRATORY PAUSE
APNEA PARAMS
100% O2
EXPIRATORY PAUSE
PEEP / CPAP
5.0
TRIGGER SENSITIVITY (L/min)
3.0
% O2
40
RESPIRATORY RATE
20
INSPIRATORY PRESSURE
TIDAL VOLUME
40
I:E RATIO
Ti
PEAK FLOW
10
RISE TIME FACTOR
PLATEAU (s)
0.0
VOLUME
ml
2000
1800
1600
1400
1200
1000
800
600
400
200
0
500
450
400
350
300
250
200
150
100
50
0
PATIENT DATA
MAND
ASSIST
SPONT
PRESSURE
10
cmH2O
hPa
MEAN PRESSURE
PEAK PRESSURE
PLATEAU PRESSURE
PEEP/CPAP
BREATH TIMING
28
RATE (/min)
I:E RATIO
INSPIRATORY TIME (s)
VOLUME
39
EXHALED VOLUME (ml)
TOTAL MINUTE VOLUME (L)
DELIVERED VOLUME (ml)
SPONT MINUTE VOLUME (L)
ALARM SETTINGS
110
HIGH RATE
HIGH TIDAL VOLUME
LOW INSP PRESSURE
LOW TIDAL VOLUME
HIGH PRESSURE
LOW MINUTE VOLUME
PRESSURE
cmH2O
hPa
90
80
70
60
50
40
30
20
10
0
-10
VENTILATOR STATUS section
VENTILATOR SETTINGS section
PATIENT DATA section

Figure 1-3. Controls and indicators on *760* Ventilator keyboard

1.10.1 VENTILATOR SETTINGS

The VENTILATOR SETTINGS section of the keyboard allows you to select the ventilation mode, breath type, and settings. For more detail on ventilation modes and breath delivery, see the *700 Series Ventilator System Operator's Manual*.

To change the mode and settings, select the mode, then the breath type, and then the ventilator settings. The keys flash during setup and mode changes to ensure that you review all pertinent settings. The keyboard is designed to minimize accidental or unintentional changes.

Table 1-5 summarizes the functions of the keys, knob, and indicators in the VENTILATOR SETTINGS section of the keyboard. Ventilator settings are also limited by these breath delivery boundaries:

- I:E ratio ≤ 4:1 for PCV (*760* Ventilator only), ≤ 3:1 for all other breath types
- Inspiratory time = 0.2 to 8 seconds (excluding plateau)
- Expiratory time ≥ 0.2 seconds
- PEEP/CPAP + SUPPORT PRESSURE or INSPIRATORY PRESSURE ≤ 80 cmH_2O (80 hPa)

NOTE:

Maximum SUPPORT PRESSURE is 70 cmH_2O, maximum INSPIRATORY PRESSURE is 80 cmH_2O.

- SUPPORT PRESSURE or INSPIRATORY PRESSURE + PEEP/CPAP < HIGH PRESSURE - 2 cmH_2O (2 hPa)
- HIGH PRESSURE (in A/C and SIMV modes) > PEEP/CPAP + 7 cmH_2O (7 hPa)
- HIGH PRESSURE (in SPONT mode) > PEEP/CPAP + SUPPORT PRESSURE + 2 cmH_2O (2 hPa)
- HIGH PRESSURE > LOW INSP PRESSURE
- Minute volume ≤ 50 L/min at an I:E ratio of 2:1

Table 1-5: *700 Series* Ventilator keyboards: VENTILATOR SETTINGS

Key/indicator	Specifies...	Range
Mode/breath type settings		
A/C	Assist/control mode.	VCV (volume control ventilation) and PCV (pressure control ventilation) breath types. (PCV available on *760* Ventilator only.)
SIMV	Synchronous intermittent mandatory ventilation mode.	VCV, PCV (*760* only), and PSV (pressure support ventilation) breath types.
SPONT	Spontaneous mode.	PSV breath type
VCV	VCV breath type.	VCV available on *740* and *760* Ventilators in A/C or SIMV modes.
PCV	PCV breath type.	PCV available on *760* Ventilator only in A/C or SIMV modes.
PSV	PSV breath type.	PSV available in SIMV or SPONT modes.
Mandatory (VCV) settings		
RESPIRATORY RATE	The minimum number of mandatory breaths the patient receives per minute.	1 to 70 /minute (non-apnea ventilation)* 6 to 70 (apnea ventilation)* Accuracy: ± (0.1 + 1%) /minute * For ventilators equipped with software revision J or later.
TIDAL VOLUME	Volume delivered to the patient during a mandatory breath, compliance-compensated and corrected to body temperature and pressure, saturated (BTPS).	40 to 2000 ml Accuracy: ± (10 ml + 10% of setting)
PEAK FLOW	Maximum flow of gas delivered during a mandatory breath (BTPS). (Combined with tidal volume, peak flow defines the active portion of inspiratory time.)	3 to 150 L/min Accuracy: ± (5 + 10% of setting) L/min
PLATEAU (s)	Length of inspiratory pause after a mandatory breath has been delivered, during which no gas is delivered.	0.0 to 2.0 second Accuracy: ± 0.05 second
Mandatory (PCV) settings (*760* Ventilator only)		
RESPIRATORY RATE	The minimum number of mandatory breaths the patient receives per minute.	1 to 70 /minute (non-apnea ventilation)* 6 to 70 (apnea ventilation)* Accuracy: ± (0.1 + 1%) /minute * For ventilators equipped with software revision J or later.
INSPIRATORY PRESSURE (*760* only)	Pressure above PEEP during the inspiratory phase of a PCV breath.	5 to 80 cmH_2O (5 to 80 hPa) Accuracy: ± (3 + 2.5% of setting) cmH_2O

Table 1-5: *700 Series* Ventilator keyboards: VENTILATOR SETTINGS (continued)

Key/indicator	Specifies...	Range
T_I/I:E RATIO (*760* only)	You can use the MENU key to select inspiratory time (T_I) or I:E ratio as the breath timing setting for a PCV breath. You can change the selected breath timing setting (T_I or I:E ratio), but the setting remains constant when you change the respiratory rate in PCV. Selecting I:E ratio makes the set ratio of inspiratory time to expiratory time for a PCV breath.	Inspiratory time (T_I): 0.2 to 8 seconds Accuracy: ± 0.05 second I:E ratio: 1:99 to 4:1 Accuracy: ± (0.1 + 2%)
RISE TIME FACTOR (*760* only)	The time for inspiratory pressure to rise from 0 to 95% of the target pressure level during a PCV breath. A setting of 100 = a 100-msec rise time, and a setting of 5 = 80% of the inspiratory time or 2500 msec, whichever is less. When this setting is changed, the message window shows the actual time (in seconds) to reach 95% of target pressure. NOTE: To help determine the correct setting for inspiratory time, during PCV the message window dislays peak inspiratory flow, end inspiratory flow, and end exhalation flow in L/min.	5 to 100
Spontaneous (PSV) settings		
SUPPORT PRESSURE	Pressure above PEEP maintained during spontaneous inspiration. Support pressure is terminated when inspiratory flow falls to 25% of peak inspiratory flow, or to the exhalation sensitivity setting (*760* only), or 10 L/min or 25% of peak flow, whichever is lower (*740* only). Maximum inspiratory time is 3.5 seconds for adults, and 2.5 seconds for pediatric patients.	0 to 70 cmH_2O (0 to 70 hPa) Accuracy: ± (3 + 2.5% of setting) cmH_2O
RISE TIME FACTOR (*760* only)	The time for inspiratory pressure to rise from 0 to 95% of the target pressure level during a PSV breath. A setting of 100 = a 100-msec rise time, and a setting of 5 = 80% of the inspiratory time or 1500 msec (when an adult ventilator breathing circuit is selected) or 600 msec (when a pediatric circuit is selected), whichever is less. When you adjust this setting, the message window shows the actual time (in seconds) to reach 95% of target pressure.	5 to 100

Table 1-5: *700 Series* Ventilator keyboards: VENTILATOR SETTINGS (continued)

Key/indicator	Specifies...	Range
EXH SENSITIVITY (*760* only)	The percent of peak expiratory flow at which the ventilator cycles from inspiration to exhalation for spontaneous breaths. The flow at which the ventilator cycles from inspiration to exhalation for PSV breaths. Exhalation begins when the inspiratory flow is less than the set value. To help set EXH SENSITIVITY appropriately, the peak inspiratory flow and end inspiratory flow are displayed in the message window in PSV.	1 to 80%* * For ventilators equipped with software revision J or later.
Common settings		
PEEP/CPAP	Positive end expiratory pressure/continuous positive airway pressure. Minimum pressure maintained during inspiratory and expiratory phases.	0 to 35 cmH_2O (0 to 35 hPa) Accuracy: ± (2 cmH_2O + 4% of setting)
TRIGGER SENSITIVITY (L/min)	Inspiratory flow required to trigger the ventilator to deliver a breath.	1 to 20 L/min
% O_2	Percentage of inspired oxygen of the gas delivered to the patient.	21 to 100% Accuracy: ± 3% full scale
	NOTE: It may take several minutes for the oxygen percentage to stabilize.	
Other keys, knob, and indicators		
APNEA PARAMS key	Allows the operator to select VCV or PCV (*760* Ventilator only) apnea ventilation, and apnea ventilation settings. Apnea ventilation is available SPONT mode, or in SIMV or A/C mode when the respiratory rate is less than 6 /minute.* You can select an apnea interval from 10 to 60 seconds.* For other apnea parameter ranges, see mandatory VCV settings and mandatory PCV (*760* Ventilator only) settings. * For ventilators equipped with software revision J or later.	
MENU	Allows you to view active and reset alarms, run SST and EST, adjust certain settings (including endotracheal tube size, humidifier type*, date and time, apnea interval*, VCV flow (ramp or square) pattern*, speaking valve setup*, alarm volume, PCV timing, and volume bar graph display), access oxygen sensor functions (calibrate, enable or disable % O_2 alarm limits, and enable or disable display of oxygen sensor reading), enter standby mode, and view battery information, display software revision, display service information, and enter *EasyNeb* nebulizer functions. (The *700 Series Ventilator System Operator s Manual* explains how to use the menu function.) * For ventilators equipped with software revision J or later.	
100% O_2	Switches the % O_2 to 100% for 2 minutes, then returns to the current % O_2 setting. The 2-minute interval restarts every time you press 100% O_2. Once the 100% O_2 has started, you can press CLEAR to stop the maneuver (unless you have entered a MENU key function or selected a setting).	

Table 1-5: *700 Series* Ventilator keyboards: VENTILATOR SETTINGS (continued)

Key/indicator	Specifies...	Range
MANUAL INSP	Delivers one mandatory breath to the patient according to the current mandatory settings (in A/C or SIMV) or the current apnea parameters (in SPONT). You can deliver a MANUAL INSP at any time during the exhalation phase of a breath as long as the exhaled flow is less than 30% of the peak exhaled flow, except during apnea ventilation.	
EXP PAUSE (*760* only)	Allows you to measure the patient's auto-PEEP. Pressing EXP PAUSE causes the ventilator to close the exhalation valve at the end of the expiratory phase, and does not deliver the next mandatory breath. At the end of the maneuver, the message window shows the calculated value for auto-PEEP (expiratory pressure at the beginning of the maneuver minus expiratory pressure at the end of the maneuver) and total PEEP for 30 seconds. The message window shows the end expiratory flow in L/min at the beginning of each breath. If there is expiratory flow when the ventilator delivers the next breath, indicates that auto-PEEP is present. The EXP PAUSE continues as long as you hold down the key, and should last only as until expiratory pressure stabilizes. An EXP PAUSE maneuver ends when you release the key, the patient initiates a breath, an alarm occurs, the expiratory phase (including the maneuver) lasts more than 20 seconds, or the ventilator detects a leak. Auto-PEEP: Range: 1 to 35 cmH_2O. Accuracy: ± (1 cmH_2O + 3% of reading).	
INSP PAUSE (*760* only)	Allows you to measure the patient's compliance and resistance. An extended inspiratory pause also allows you to expand the patient's lungs for up to 10 seconds. Pressing INSP PAUSE momentarily causes the ventilator to wait until the end of the inspiratory phase of the current or next mandatory breath (in SPONT mode, the ventilator delivers a mandatory breath using the MANUAL INSP key according to the apnea settings), stop breath delivery, and keep the exhalation valve closed. The INSP PAUSE continues until the ventilator detects a stable plateau pressure or 2 seconds have elapsed. An INSP PAUSE maneuver ends when a stable plateau is reached or an alarm occurs. Pressing INSP PAUSE for 2 or more seconds after the pause begins causes the ventilator to deliver an inspiratory pause for as long as you hold down the key. An extended INSP PAUSE maneuver ends when you release the key or 10 seconds have elapsed. You can press CLEAR or release the INSP PAUSE key at any time to cancel an INSP PAUSE maneuver. At the end of the breath, the message window shows the calculated value for compliance and resistance (if the mandatory breath was a VCV breath) or compliance (if the mandatory breath was a PCV breath) for 30 seconds. Compliance: Range: 1 to 150 mL/H_2O. Accuracy: ± (1 mL/cmH_2O + 20% of reading). Resistance: Range: 0 to 150 cmH_2O/L/second. Accuracy: ± (3 cmH_2O/L/second + 20% of reading).	
CLEAR	Pressing CLEAR before accepting a setting cancels the proposed setting. Pressing CLEAR does not cancel accepted settings. Pressing CLEAR twice returns the ventilator to its previous state (unless you have entered a MENU key function that requires you to press CLEAR more times). Pressing CLEAR during a 100% O_2 maneuver cancels the maneuver.	
ACCEPT	Makes changes to settings effective. If you don't press ACCEPT within 30 seconds of proposing a new setting, the user interface returns to its previous state.	

Table 1-5: *700 Series* Ventilator keyboards: VENTILATOR SETTINGS (continued)

Key/indicator	Specifies...	Range
Knob	Adjusts the value of a setting or selects a menu option. A setting value that flashes means that the knob is linked to that setting. Turning the knob clockwise increases the value, and turning the knob counterclockwise decreases the value.	
CURRENT	Lights when the ventilator is operating according to the displayed settings, or during apnea ventilation. (There is one indicator for mandatory breaths, and one for spontaneous breaths.)	
PROPOSED	Lights when you propose a mode or breath type, or you are setting apnea parameters. Once a proposed setting is accepted, it becomes effective at the next breath.	
APNEA PARAMS indicator	Lights when apnea ventilation is active. Lights with PROPOSED indicator when you are setting apnea parameters, and both indicators turn off once apnea parameters are accepted.	
Message window	Shows up to four lines of information (20 characters per line). *First line*: Reserved for the highest-priority active or autoreset alarm. On the *760* Ventilator and for *740* Ventilators with software revision H or later, if no alarm is active and the display of the oxygen sensor reading is enabled, the % O_2 is displayed here. If VCV is the current or proposed breath type, the VCV flow pattern is also displayed if there are no active or autoreset alarms. *Second line*: Information about the menu function or settings, alarm silence time remaining, or current date and time. On the *760* Ventilator and for *740* Ventilators with software revision H or later during normal ventilation, shows "*Flow (L/min)*." Third and fourth lines: Reserved for other messages. On the *760* Ventilator and for *740* Ventilators with software revision H or later for every breath type, peak and end inspiratory flows are displayed on the third line, and end expiratory flow is displayed on the fourth line (except that inspiratory flow is not displayed during VCV breaths or VCV apnea ventilation).	

1.10.2 PATIENT DATA

The PATIENT DATA section of the keyboard allows you to view the pressure, breath timing, and volume of the patient's breath. You can also view or change the alarm settings. A lighted key indicates that a measurement is selected, and its value appears in the display window. Values are continuously displayed and updated during ventilation.

Table 1-6 summarizes the functions of the keys and indicators in the PATIENT DATA section of the keyboard.

Table 1-6: *700 Series* Ventilator keyboards: PATIENT DATA

Key/indicator	Function	Range
Pressure		
MEAN PRESSURE	Shows the calculated value of ventilator breathing circuit pressure over an entire respiratory cycle. Updated at the beginning of each breath.	0 to 99 cmH_2O (0 to 99 hPa) Accuracy: ± (3 + 4% of reading) cmH_2O
PEAK PRESSURE	Shows the maximum pressure measured during inspiration. Updated at the beginning of each expiratory phase. (Default pressure display.)	0 to 140 cmH_2O (0 to 140 hPa) Accuracy: ± (3 + 4% of reading) cmH_2O
PLATEAU PRESSURE (*760* only)	Shows the pressure measured at the end of the plateau period of a mandatory inspiration (whether the inspiration is in a regular VCV breath or is part of an inspiratory pause maneuver). Updated at the beginning of each expiratory phase. The PRESSURE display shows a blank if the ventilator does not detect a stable plateau pressure.	0 to 140 cmH_2O (0 to 140 hPa) Accuracy: ± (3 + 4% of reading) cmH_2O
PEEP/CPAP (*760* only)	Shows the pressure measured at the expiratory limb before any inspiratory effort. Updated at the beginning of each inspiratory phase.	0 to 140 cmH_2O (0 to 140 hPa) Accuracy: ± (3 + 4% of reading) cmH_2O

Table 1-6: *700 Series* Ventilator keyboards: PATIENT DATA (continued)

Key/indicator	Function	Range
Breath timing		
RATE (/min)	Shows the calculated value of the total respiratory rate, based on the previous 60 seconds or 8 breaths (whichever interval is shorter). Updated at the beginning of each breath. (Default breath timing display.) The calculation is reset (and display is blank) when ventilation starts, when apnea ventilation starts or autoresets, when you change the mode, breath type, or RESPIRATORY RATE setting, and when you press the alarm reset key.	1* to 500 /minute Accuracy: ± (0.1 +1% of reading)/minute * For ventilators equipped with software revision J or later.
I:E RATIO	Shows the ratio of measured inspiratory time to measured expiratory time. Updated at the beginning of each breath.	1:99.9 to 9.9:1 Accuracy: ± (0.1 + 2%)
INSP TIME (s) (*760* only)	The measured inspiratory time, including breaths that are truncated due to a HIGH PRESSURE alarm. Updated at the beginning of each expiratory phase.	0.00 to 9.90 seconds Accuracy: ± 0.05 seconds
Volume		
EXHALED VOLUME (ml)	Shows the patient's measured expiratory tidal volume averaged over the last 5 breaths (for A/C VCV breaths, ventilator-initiated PCV breaths, and PCV apnea breaths) or for the just-completed breath (for all other breaths). Corrected to BTPS and compliance-compensated. Updated at the beginning of each inspiration. (Default volume display.) The calculation is reset when ventilation starts, when apnea ventilation starts or autoresets, when you change the mode, breath type, or any setting that affects breath averages (for example, respiratory rate or inspiratory time), and when you press the alarm reset key.	0 to 9 L Accuracy: ± (10 ml + 10% of reading)

Table 1-6: *700 Series* Ventilator keyboards: PATIENT DATA (continued)

Key/indicator	Function	Range
TOTAL MINUTE VOLUME (L)	Shows the patient's measured expiratory minute volume, based on the previous 60 seconds or 8 breaths (whichever interval is shorter). Updated at the beginning of each breath. The calculation is reset when ventilation starts, when apnea ventilation starts or autoresets, when you change the mode or breath type, and when you press the alarm reset key.	0 to 99 L Accuracy: ± (10 ml + 10% of reading)
DELIVERED VOLUME (mL) (*760* only)	Shows the measured inspiratory tidal volume for the just-completed PCV or PSV breath. Corrected to BTPS and compliance-compensated. Updated at the beginning of each inspiration.	0 to 3000 ml Accuracy: ± (10 ml + 10% of reading)
SPONT MINUTE VOLUME (L) (*760* only)	Shows the patient's measured expiratory minute volume for all spontaneous breaths, based on the previous 60 seconds or 8 breaths (whichever interval is shorter). Updated at the beginning of each breath. The calculation is reset when ventilation starts, when apnea ventilation starts or autoresets, when you change the mode or breath type, and when you press the alarm reset key.	0 to 99 L Accuracy: ± (10 ml + 10% of reading)
Alarm settings		
HIGH RATE	An active alarm indicates that measured respiratory rate is higher than the alarm setting.	3 to 100 /minute Accuracy: ± (0.1 +1% of setting)/minute
HIGH TIDAL VOLUME	An active alarm Indicates that exhaled volume for three out of four consecutive breaths was above the alarm setting.	20 to 6000 ml Accuracy: ± (10 ml + 10% of setting)
LOW INSP PRESSURE	An active alarm indicates that monitored circuit pressure is below the alarm setting at the end of inspiration. Inactive in SPONT mode unless the speaking valve option is enabled.	3 to 60 cmH_2O (3 to 60 hPa) Accuracy: ± (1 + 3% of setting)

Table 1-6: *700 Series* Ventilator keyboards: PATIENT DATA (continued)

Key/indicator	Function	Range
LOW TIDAL VOLUME	An active alarm indicates that exhaled volume for three out of four consecutive breaths were below the alarm setting. (If this alarm is set to 0 ml and breath type is PCV or PSV, an active alarm indicates that delivered volume is less than 3 ml for three out of four consecutive breaths.)	0 to 2000 ml Accuracy: ± (10 ml + 10% of setting)
HIGH PRESSURE	An active alarm indicates that two consecutive breaths were truncated because circuit pressure reached the alarm setting.	10 to 90 cmH_2O (10 to 90 hPa) Accuracy: ± (1 + 3% of setting)
LOW MINUTE VOLUME	An active alarm indicates that monitored minute volume is less than the alarm setting, based on an eight-breath running average or the previous minute, whichever is less.	0 to 50 L Accuracy: ± (10 ml + 10% of setting)
Other indicators		
Pressure bar graph	Shows real-time pressures in centimeters of water (cmH_2O) or hectopascals (hPa). LEDs show the current HIGH PRESSURE alarm setting and the peak pressure of the last breath during exhalation.	-10 to 90 cmH_2O (-10 to 90 hPa) Resolution: 1 cmH_2O (1 hPa)
Volume bar graph (*760* only)	Shows real-time exhaled volume in milliliters (ml). Volumes are compliance-compensated and corrected to BTPS. The active scale is determined by the HIGH TIDAL VOLUME alarm setting. LEDs show the current HIGH TIDAL VOLUME and LOW TIDAL VOLUME alarm settings. You can use the MENU key to enable or disable the volume bar graph. During exhalation, LEDs show the maximum exhaled volume of the last breath.	If HIGH TIDAL VOLUME setting < 500 ml: 0 to 500 ml Resolution: 5 ml If HIGH TIDAL VOLUME setting ≥ 500 ml: 0 to 2000 ml Resolution: 20 ml
MAND	Lights at the start of each breath to indicate a ventilator- or operator-initiated mandatory breath is being delivered.	Not applicable

Table 1-6: *700 Series* Ventilator keyboards: PATIENT DATA (continued)

Key/indicator	Function	Range
ASSIST	Lights at the start of each breath to indicate a patient-initiated mandatory breath is being delivered.	Not applicable
SPONT	Lights at the start of each breath to indicate a patient-initiated spontaneous breath is being delivered.	Not applicable

1.10.3 VENTILATOR STATUS

The VENTILATOR STATUS section of the keyboard shows the operating condition of the ventilator, and is continuously updated during operation. Table 1-7 summarizes the functions of the keys and indicators in the VENTILATOR STATUS section of the keyboard.

Table 1-7: *700 Series* Ventilator keyboards: VENTILATOR STATUS

Key/indicator	Color (Priority)	Function
ALARM	Red (high)	Flashes when a high-priority alarm is active. A repeating sequence of three, then two beeps sounds. Lights steadily when a high-priority alarm has been autoreset.
CAUTION	Yellow (medium)	Flashes when a medium-priority alarm is active. A repeating sequence of three beeps sounds. Lights steadily when a medium-priority alarm has been autoreset.
NORMAL	Green	Lights when no alarm condition is present.
VENT INOP	Red (high)	Lights to indicate that the ventilator is inoperative, and the ventilator safety valve is open. A qualified service technician must run and pass the extended self-test (EST) before normal ventilation can resume. If the condition that caused the safety valve to open no longer exists, and the VENT INOP indicator is off, press the alarm reset key to resume ventilation.
SAFETY VALVE OPEN	Red (high)	Lights when the ventilator's safety valve and exhalation valve open and only room air is available to the patient. Can indicate that the ventilator is inoperative, or there is an occlusion in the ventilator breathing circuit. If possible, the message window shows the alarm that triggered the safety valve open condition and how much time has elapsed since the last breath was triggered.
ON AC/ BATTERY CHARGING	Green	Lights when the ventilator is running on ac power and the battery is charging.
ON INTERNAL BATTERY	Yellow	Flashes when the ventilator is running on the internal battery.
ON EXTERNAL BATTERY	Yellow	Flashes when the ventilator is running on the external battery.
INTERNAL BATTERY LEVEL	Green	Shows the relative charge level of the internal battery. Flashes when ventilator runs on internal or external battery power, lights steadily when ventilator runs on ac power.
🔇 **2 min**	Yellow	**Alarm silence**: Silences the alarm sound for 2 minutes from the most recent key press.
🔊 **RESET**	Not applicable	**Alarm reset:** Reestablishes all alarm indicators, cancels the alarm silence period, and resets the patient data displays. If the condition that caused the alarm still exists, the alarm reactivates. Cancels apnea ventilation, if active. Reestablishes previous settings and ventilation resumes, unless the ventilator is inoperative.

1.11 Location of ventilator serial number

A serial number plate is affixed to the front of the ventilator near the bottom.

1.12 Determining software revision

The software revision is displayed when you power on the ventilator. You can also determine the ventilator's software revision by using the *Software revision* menu option (see the *700 Series Ventilator System Operator's Manual* for more information on the MENU key).

1.13 Service philosophy

Field service of the ventilator is limited to the service activities described in this manual. For field service, technical support, or information on technical training, call 1-800-635-5267 (within the USA) or contact your Nellcor Puritan Bennett representative (outside the USA).

1.14 Reference documentation

G-061988-00	*700 Series Ventilator System Operator's Manual* (Czech)
G-061989-00	*700 Series Ventilator System Operator's Manual* (Dutch)
G-061874-00	*700 Series Ventilator System Operator's Manual* (English)
G-061981-00	*700 Series Ventilator System Operator's Manual* (French)
G-061980-00	*700 Series Ventilator System Operator's Manual* (German)
G-061982-00	*700 Series Ventilator System Operator's Manual* (Italian)
G-061987-00	*700 Series Ventilator System Operator's Manual* (Japanese)
G-061985-00	*700 Series Ventilator System Operator's Manual* (Polish)
G-061984-00	*700 Series Ventilator System Operator's Manual* (Portuguese)
G-061986-00	*700 Series Ventilator System Operator's Manual* (Russian)
G-061983-00	*700 Series Ventilator System Operator's Manual* (Spanish)

Theory of operation

This section details the operational theory of the *700 Series Ventilator System*. It begins by describing the overall operation of the ventilator and continues by describing the pneumatic system, including the individual components and their operations as subsystems. Next it describes the electrical system, including the operations of the printed circuit boards (PCBs). Finally it describes the interactions between all ventilator components during breath delivery and under certain other conditions.

2.1 Overview of ventilator operation

The *700 Series Ventilator System* (Figure 2-1) consists of two major systems: the pneumatic system and the electrical system. The pneumatic system, under control of the breath delivery (BD) microprocessor, supplies air and oxygen to the patient system external to the ventilator. The electrical system powers the ventilator and provides electronic control of the ventilator's components. It includes five printed circuit boards (PCBs), a power supply, and various minor components (fans, harnesses, etc.).

Room air and oxygen from an external supply enter the cylinder via the mixing manifold. The piston/cylinder assembly, which is driven by the motor, mixes the gases and precisely controls the flow to the patient. An important aspect of the piston-based pneumatic system is that no contact occurs between the piston and cylinder wall; there is a minute gap. Because the piston and cylinder do not touch, friction between the piston and cylinder is eliminated, improving the ventilator's performance and reducing wear on the parts.

The output mixture of air and oxygen passes through the inspiration manifold and a patient system external to the ventilator; this patient system may be composed of tubing, filters, water traps, and a humidification device. The patient exhales the gas through the opened exhalation valve.

Pressure transducers provide feedback measurements to the BD microprocessor. After undergoing digital conversion, these measurements are used in calculations that control ventilation.

Initial settings and data for use by the microprocessor are entered by the operator via the user interface (UI). The data is processed by the UI microprocessor, then stored in the ventilator memory. The BD microprocessor uses this data to control the flow of gas to the patient system. Power to operate the ventilator comes from the ac mains (via a 24 V dc power supply output), or from an internal or external (optional) rechargeable backup battery. The external battery (if present) is used if ac power is interrupted. The internal battery is used if the external battery is exhausted or not present. The external battery can be connected or disconnected without any interruption in ventilation.

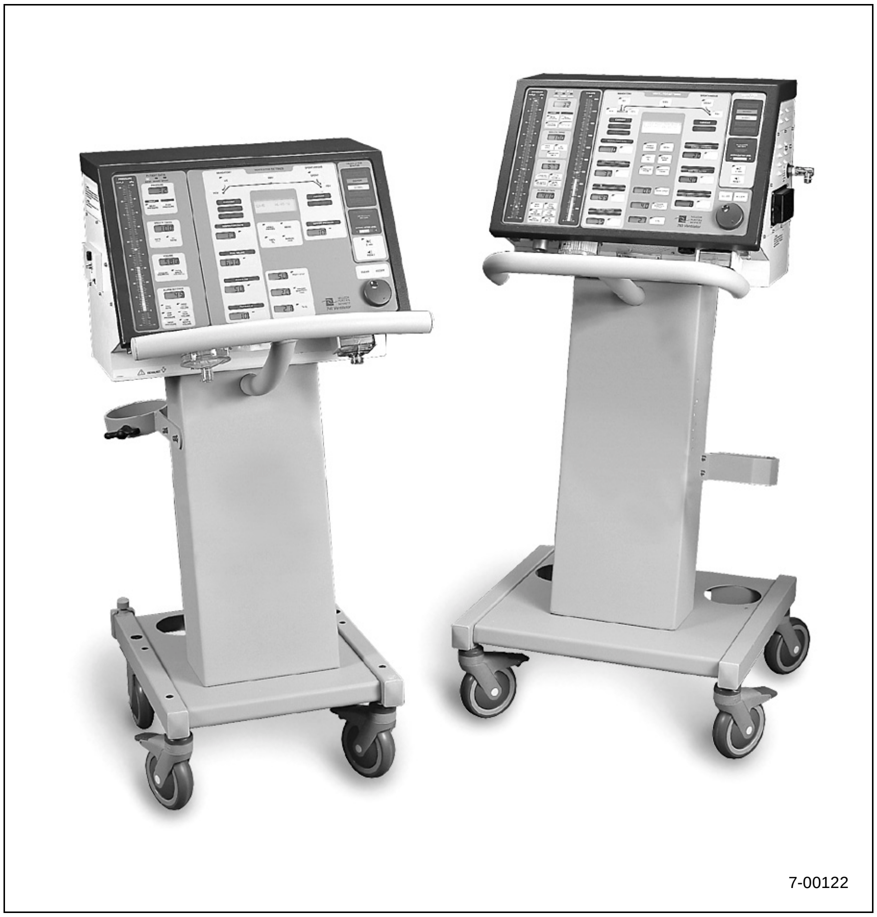


Figure 2-1. ***700 Series Ventilator Systems***

2.2 Pneumatic system

The *700 Series* Ventilator pneumatic system includes the following (see Figure 2-2):

- Gas inlet system
- Piston/cylinder system
- Inspiratory manifold system
- Patient system
- PEEP/CPAP system
- Exhalation system

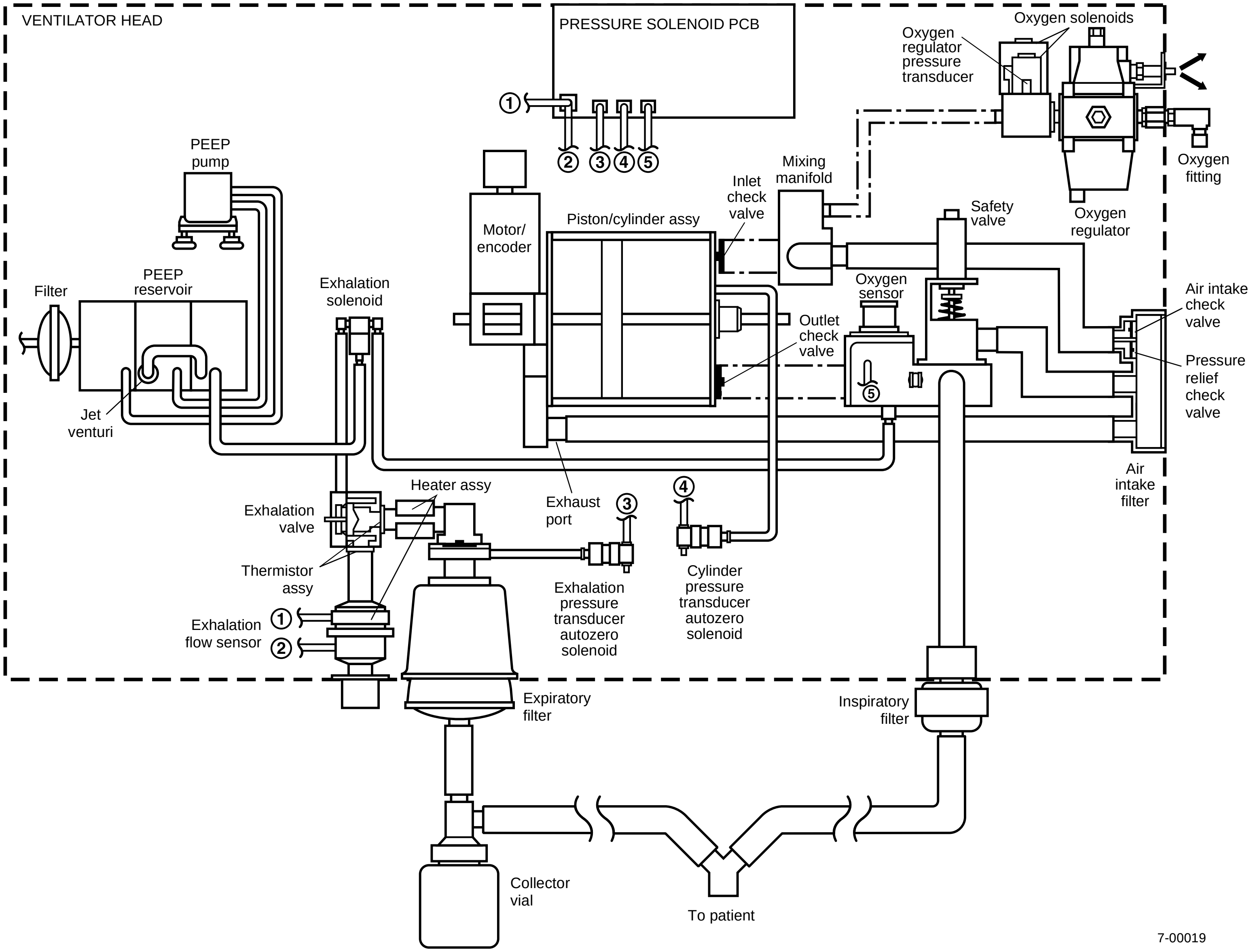

VENTILATOR HEAD
PRESSURE SOLENOID PCB
①
②
③
④
⑤
Oxygen solenoids
Oxygen regulator pressure transducer
Oxygen fitting
Oxygen regulator
PEEP pump
Mixing manifold
Inlet check valve
Safety valve
Motor/ encoder
Piston/cylinder assy
Oxygen sensor
Filter
PEEP reservoir
Exhalation solenoid
Outlet check valve
Air intake check valve
Pressure relief check valve
Jet venturi
Air intake filter
Heater assy
Exhaust port
Exhalation valve
Thermistor assy
Exhalation pressure transducer autozero solenoid
Cylinder pressure transducer autozero solenoid
Exhalation flow sensor
Expiratory filter
Inspiratory filter
Collector vial
To patient
7-00019

Figure 2-2. Pneumatic system

Table 2-1 provides some pertinent specifications and other data for the ventilator's pneumatic components.

Table 2-1: Pneumatic component data

Component	Data
Check valve, air intake, inlet	Opens to draw in room air. Closes during oxygen delivery to reduce noise.
Check valve, air intake pressure relief	Remains closed during normal operation. Opens at or below 5 cmH_2O to prevent excess pressure in the intake duct.
Check valve, cylinder inlet	Opens during piston retraction to draw in room air and/or oxygen
Check valve, cylinder outlet	Opens to deliver mixed gas to the patient
Check valve, exhalation	Opens during exhalation to permit exhaled gas into the exhalation system. Prevents rebreathing.
Collector vial	Collects moisture in the exhaled gas to keep water from occluding the expiratory filter or entering the exhalation system.
Exhalation valve	Piloted by exhalation solenoid. Opened during exhalation (as required to maintain PEEP/CPAP). Closed during inspiration.
Filter, air intake	≥5 µm retention
Filter, expiratory	>0.3 µm nominal (and larger) retention at flow of 100 L/min
Filter, inspiratory (main flow)	>0.3 µm nominal (and larger) retention at flow of 100 L/min
Filter, PEEP reservoir	>0.3 µm nominal (and larger) retention at a flow of 10 L/min
Fitting, oxygen (source)	DISS (diameter index system standard) male. DISS female and male, NIST (non-interchangeable screw thread), Air Liquide, Australian type, and Dräger oxygen hose kits available, using adapters as necessary.
Heater assembly, exhalation	Two 10 W heaters that maintain temperature of exhalation assembly walls above condensation point
Piston/cylinder assembly (includes piston/cylinder, motor/encoder, and optoswitches)	Includes a brushless dc motor. Can deliver up to 2 L nominal. Clearance of 50 µm (0.002 in.) between piston and cylinder wall.
Pump, PEEP	Supplies PEEP pilot pressure of 0 to 25 cmH_2O
Regulator, oxygen	Output of 33 ± 5 psi (227.46 ± 34.48 kPa) throughout supply pressure range of 40 to 90 psi (275 to 620 kPa) (no flow). Includes internal filter (5 µm retention) and outlet filter (>30 µm retention). Maximum 3 L/min bleed.
Sensor, exhalation flow	A mesh screen with pressure taps on both sides. Pressure drop across screen monitored by a differential pressure transducer and used to determine flow.
Sensor, oxygen	Measures percentage of oxygen in inspired gas (based on partial pressure of oxygen). Range: 18 to 103% oxygen.
Solenoid, autozero, cylinder pressure transducer	Three-way *De-energized (closed):* Except when transducer is autozeroed. *Energized (opened):* When transducer is autozeroed (upon power-on, once a minute for first 10 minutes, then hourly).

Table 2-1: Pneumatic component data (continued)

Component	Data
Solenoid, autozero, exhalation pressure transducer	Three-way. *De-energized (closed):* During normal operation. *Energized (opened):* When transducer is autozeroed (upon power-on, once a minute for first 10 minutes, then hourly).
Solenoid, exhalation	Three-way *De-energized:* Pilots exhalation valve with PEEP pilot pressure. During exhalation. *Energized:* Pilots exhalation valve with inspiration gas. During inspiration.
Solenoid, safety valve	Three-way *De-energized (opened):* Under software control: Due to a ventilator inoperative (VENT INOP) condition (including when pressure exceeds 92 cmH_2O) and during POST. By dedicated circuit: at 115 cmH_2O under hardware control. *Energized (closed):* All other times.
Solenoid assembly, oxygen (includes low- and high-flow solenoids, and orifices)	High-flow solenoid: Two-way *Energized (opened):* High oxygen flow requirements. *De-energized (closed):* Other times. Low-flow solenoid: Two-way *Energized (opened):* Low oxygen flow requirements. *De-energized (closed):* Other times.
Switch, air intake filter	A microswitch located in the air intake manifold, which is actuated when an air intake filter is present.
Thermistor, inspiration manifold	Measures inspiration gas temperature.
Thermistor assembly, exhalation	Measures temperature of blanket heater.
Transducer, pressure, cylinder	Measures cylinder pressure. On pressure solenoid PCB.
Transducer, pressure, exhalation flow sensor	Monitors pressures on both sides of flow sensor screen. Flow is determined from pressure drop. On pressure solenoid PCB.
Transducer, pressure, exhalation	Measures pressure of exhaled gas. On pressure solenoid PCB.
Transducer, pressure, inspiration	Measures inspiratory pressure and absolute atmospheric pressure. On pressure solenoid PCB.
Transducer, pressure, oxygen regulator	Measures oxygen source pressure at oxygen solenoid assembly.

2.2.1 Gas Inlet System Overview

The gas inlet system, shown in Figure 2-3 and Figure 2-4, entrains room air. It also delivers externally supplied oxygen to the ventilator and regulates the oxygen to a pressure usable by the ventilator.

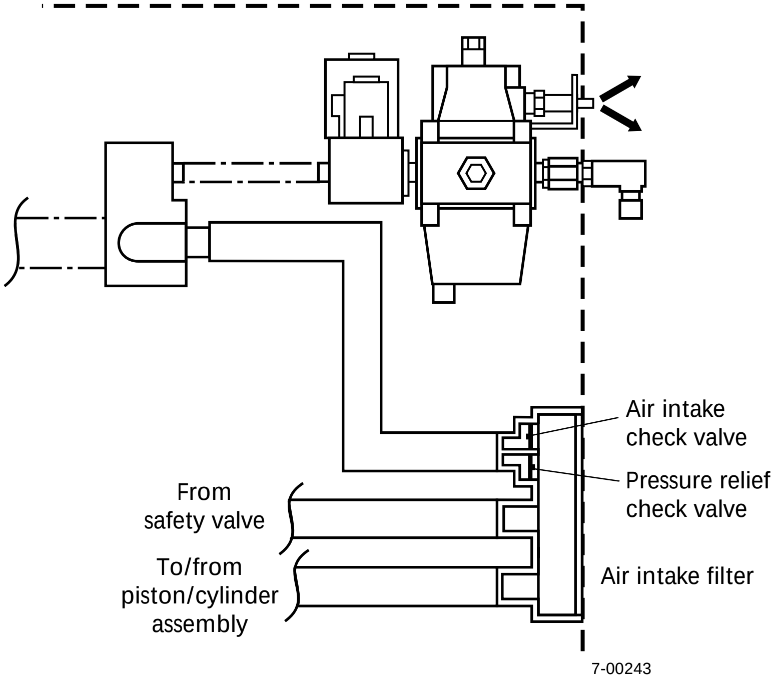
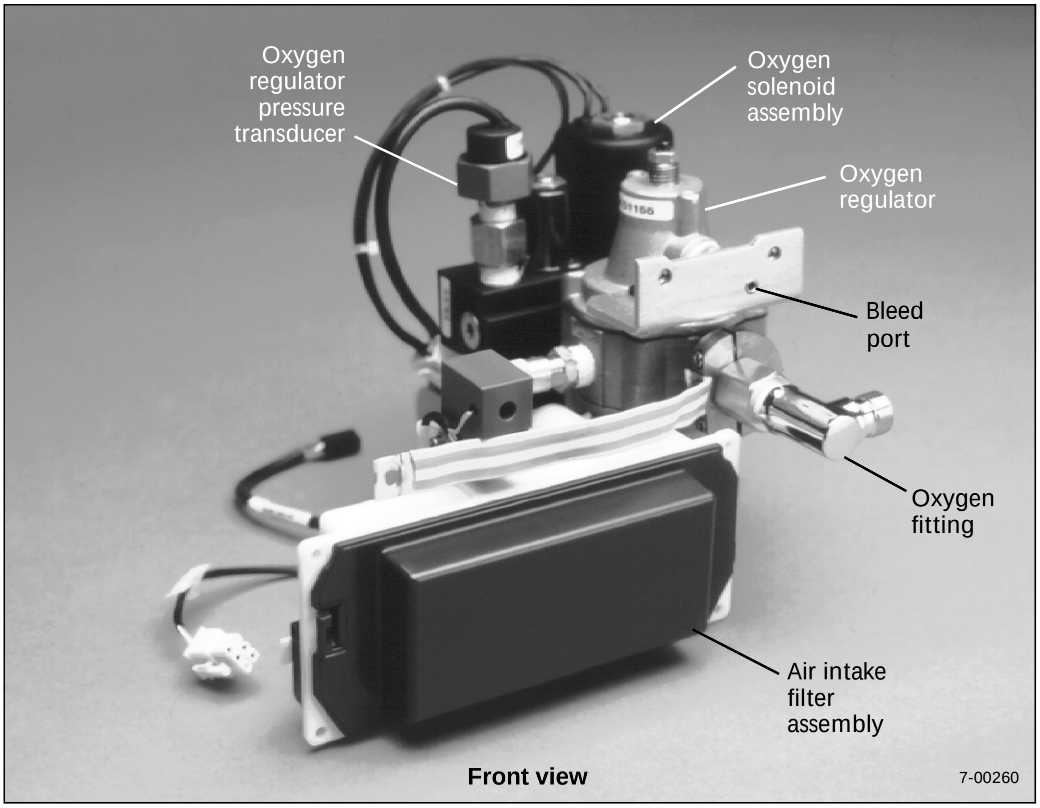

Air intake check valve
Pressure relief check valve
From safety valve
To/from piston/cylinder assembly
Air intake filter
7-00243

Figure 2-3. Gas inlet system pneumatic diagram


Oxygen regulator pressure transducer
Oxygen solenoid assembly
Oxygen regulator
Bleed port
Oxygen fitting
Air intake filter assembly
Front view
7-00260

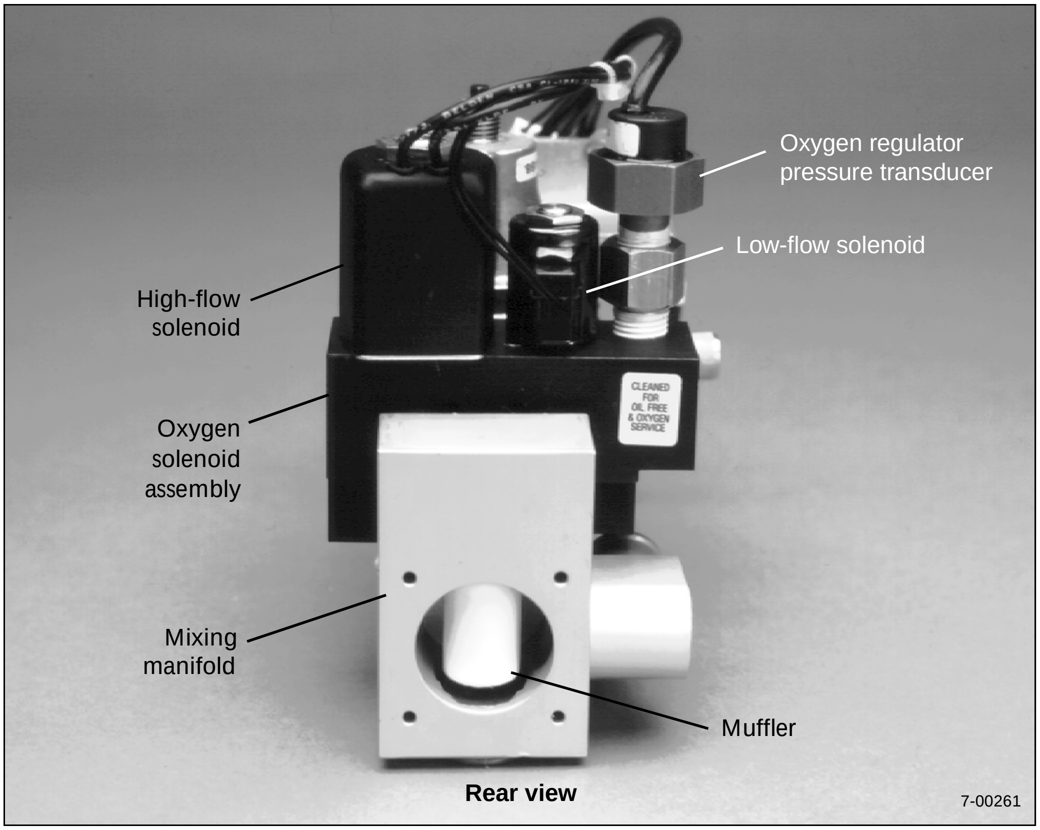
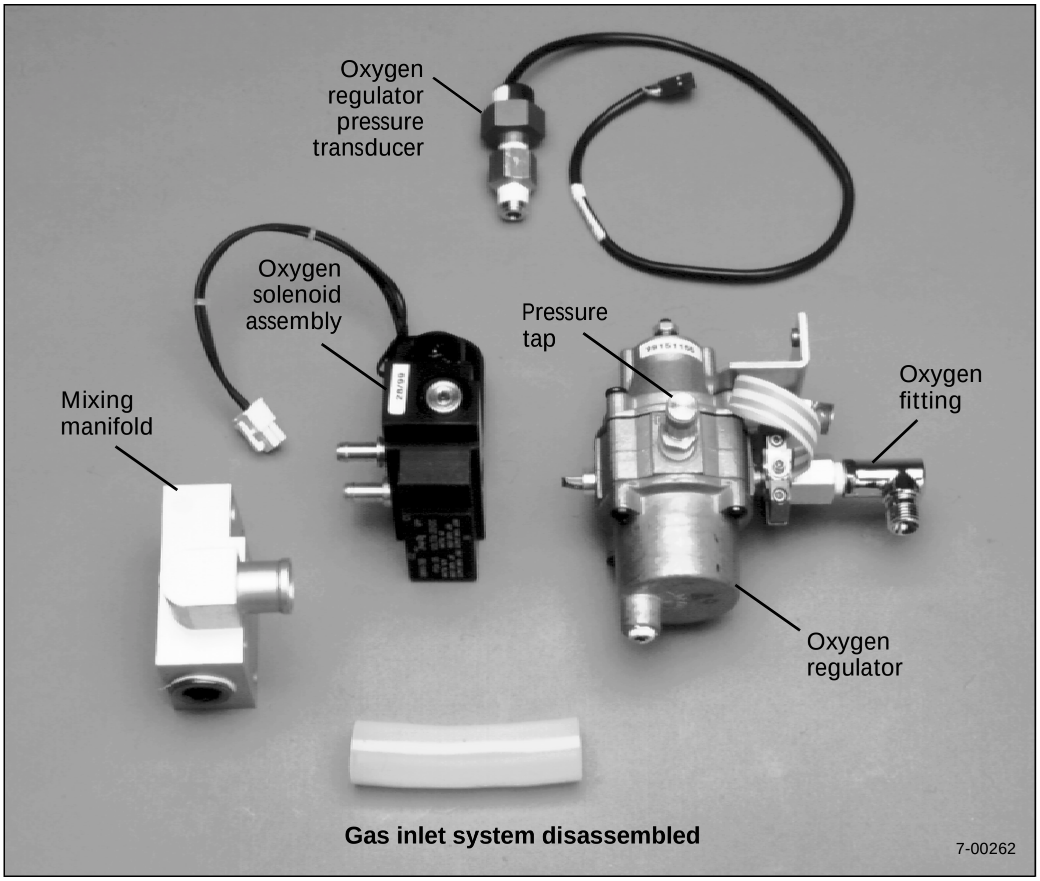
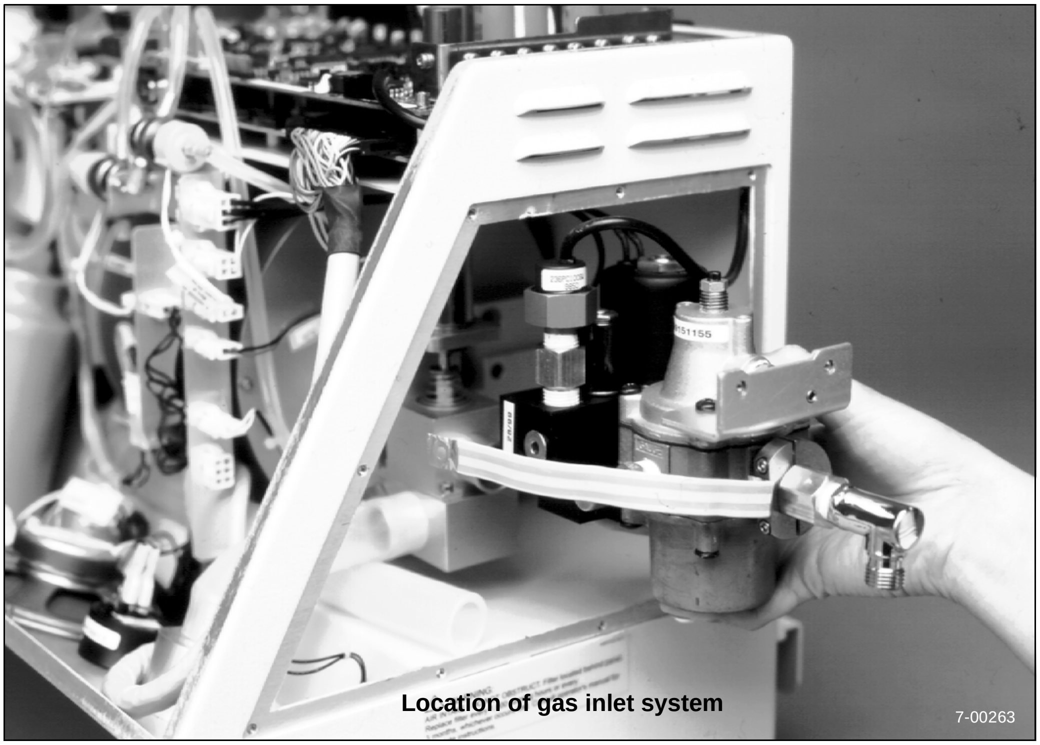

Oxygen regulator pressure transducer
Low-flow solenoid
High-flow solenoid
Oxygen solenoid assembly
Mixing manifold
Muffler
CLEANED FOR OIL FREE & OXYGEN SERVICE
Rear view
7-00261

Figure 2-4. Gas inlet system (1 of 2)


Oxygen regulator pressure transducer
Oxygen solenoid assembly
Pressure tap
Oxygen fitting
Mixing manifold
Oxygen regulator
7-00262

Gas inlet system disassembled



Location of gas inlet system

Figure 2-4. Gas inlet system (2 of 2)

2.2.1.1 Gas inlet system components

The gas inlet system includes the components described below; these are shown in Figure 2-5.

- The **air intake cover** holds the air intake filter element in place and protects it from contact with liquids.
- The **air intake filter**, mounted just inside the ventilator cabinet, captures airborne particles as small as 5 µm. The filter is replaced every 1000 hours, or more often as necessary.
- The **air intake manifold** provides an intake for the mixing manifold. It has an outlet, which provides a filtered path to atmosphere for the piston/cylinder. It also provides a vent for the safety valve. An inlet check valve opens to allow room air intake, and closes to dampen noise during the oxygen mixing process. A relief check valve relieves any excess pressure in the intake duct.
- The **oxygen fitting** and **hose** connect an external oxygen source (wall or cylinder) to the ventilator. The choice of available oxygen fittings supports use of female DISS (diameter index system standard), male DISS, NIST (non-interchangeable screw thread), Air Liquide, Australian type, and Dräger hose assemblies.

Warning

To ensure adequate oxygen delivery to the patient, use Nellcor Puritan Bennett-supplied oxygen hoses only. Use of other oxygen hoses could result in inadequate or inappropriate oxygen pressures or leaks at the oxygen inlet.

- The oxygen solenoid assembly is a field-replaceable unit (FRU). This assembly includes the high- and low-flow solenoids, and does *not* include the oxygen regulator pressure transducer. Calibration data specific to each solenoid assembly is recorded in NVRAM; this data must be updated when a new assembly is installed.
- The **oxygen regulator** is a FRU, which is replaced every 15,000 hours. The oxygen regulator assembly does *not* include the oxygen regulator pressure transducer.

  The **oxygen regulator** is a self-relieving regulator that maintains a stable output pressure of 33 ± 5 psi (227.46 ± 34.48 kPa) throughout the supply pressure range of 40 to 90 psi (275 to 620 kPa) under no-flow conditions. It is factory-calibrated to obtain 150 L/min STPD through the high-flow orifice. Performing a Reg altitude calib (Section 4.2.3.2.2) at high altitudes decreases this pressure to a level that is appropriate for the altitude at which the calibration is performed.

  A sintered bronze 5-µm filter inside the regulator prevents particles from entering. A stainless steel screen outlet filter removes particles of 30 (µm) or larger from the regulated oxygen.

  A bleed of up to 3 L/min improves the regulator's performance and response time at low flow rates. The regulator's vent is directed outside the ventilator to prevent a buildup of oxygen inside the ventilator.

Warning

Due to excessive restriction of the Air Liquide, Dräger, and Australian hose assemblies, reduced FIO_2 levels may result when oxygen inlet pressures < 50 psi (345 kPa) are employed. Make sure oxygen inlet pressure is ≥ 50 psi (345 kPa) when using these hose assemblies, to maintain correct FIO_2 levels.

NOTE:

To prevent depletion of oxygen supply, disconnect oxygen from ventilator when oxygen is not in use. Any time oxygen is connected, whether or not an oxygen-enriched patient mixture is selected, the oxygen regulator bleeds up to 3 L/min.

The regulator has a pressure tap to permit the attachment of a fixture for oxygen regulator pressure transducer calibration.

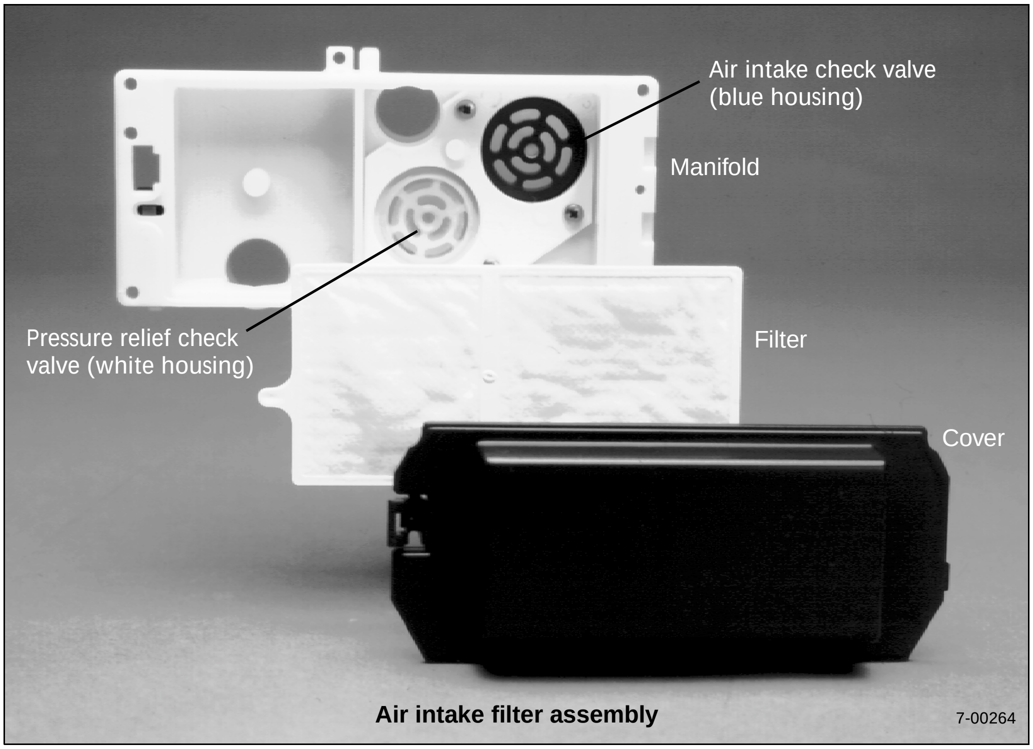
The regulator has a pressure drop of 6 to 7 psig when the high-flow oxygen solenoid is energized (at 150 sL/min).

- The **oxygen solenoid assembly** includes two two-way solenoids and two critical flow orifices. Whenever the ventilator is set for an oxygen concentration greater than 21%, these solenoids/orifices deliver oxygen to the mixing manifold. Only one of these solenoids is energized with each breath. The larger (high-flow) solenoid and orifice can deliver higher flows, while the smaller (low-flow) solenoid and orifice can deliver lower flows. For more information about the oxygen solenoids and oxygen mixing, see Section 2.6.4.
- The **oxygen regulator pressure transducer** measures the oxygen pressure at the oxygen solenoid assembly. These oxygen pressure measurements are used to monitor the oxygen source pressure to verify its adequacy and to calculate the flow from the orifices. If the oxygen pressure reading drops below a threshhold level (determined by real-time atmospheric pressure measurements) for two consecutive breaths, or if oxygen flow from the high-flow orifice drops below 100 L/min for two consecutive breaths, the ventilator invokes a low oxygen supply alarm.
- Filtered room air and the precisely controlled oxygen flow pass through the **mixing manifold**. This chamber has a muffler, which dampens the sound of the mixing gases.

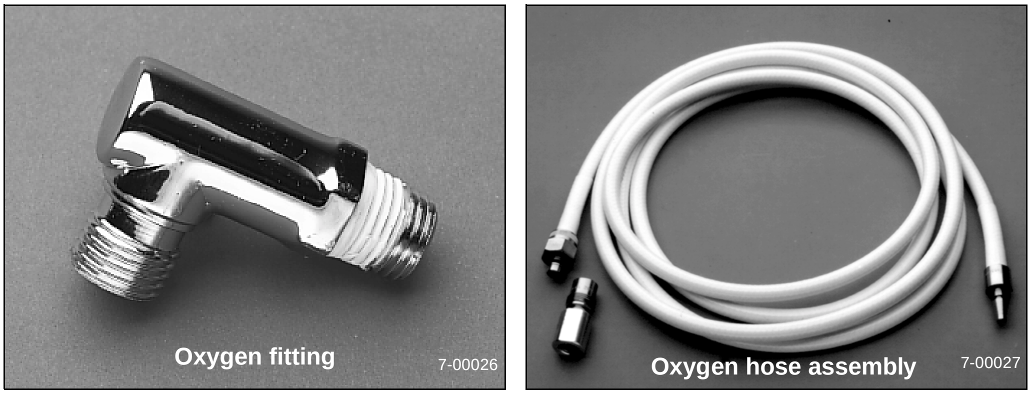
2.2.1.2 System operation

During piston retraction, oxygen and/or room air are drawn into the cylinder. If oxygen enrichment is selected, oxygen from an external source is regulated, then supplied by either the low- or high-flow solenoid/orifice. Room air to be used in the mixture is drawn in through the air intake filter. The gases pass through the mixing manifold, which dampens the sound of the gases. The gas displaced by piston movement is vented through the air intake filter also.

During gas delivery, the oxygen system is pressurized, but there is no flow, as the oxygen solenoids are de-energized (closed).


Air intake check valve (blue housing)
Manifold
Pressure relief check valve (white housing)
Filter
Cover
7-00264

Air intake filter assembly


7-00026
7-00027

Oxygen fitting

Oxygen hose assembly

Figure 2-5. Gas inlet system components (1 of 2)

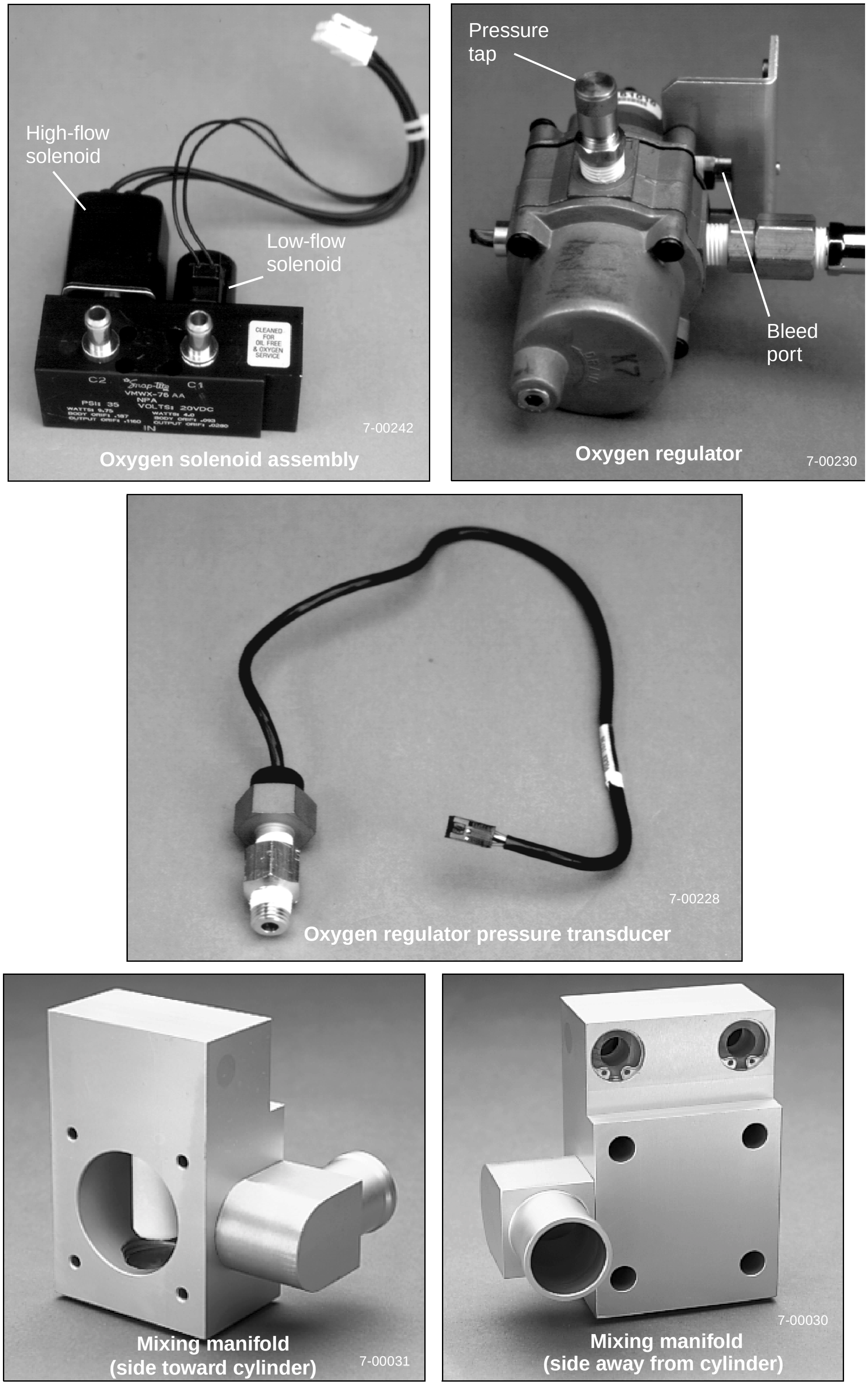

High-flow solenoid
Low-flow solenoid
CLEANED FOR OIL FREE & OXYGEN SERVICE
C2
Snap-tite
C1
VMWX-75 AA
NPA
PSI: 35
VOLTS: 20VDC
WATTS: 9.75
BODY ORIF: .187
OUTPUT ORIF: .1160
WATTS: 4.0
BODY ORIF: .093
OUTPUT ORIF: .0280
IN
7-00242
Oxygen solenoid assembly
Pressure tap
Bleed port
Oxygen regulator
7-00230
7-00228
Oxygen regulator pressure transducer
Mixing manifold (side toward cylinder)
7-00031
7-00030
Mixing manifold (side away from cylinder)

Figure 2-5. Gas inlet system components (Sheet 2 of 2)

2.2.2 Piston/cylinder system

The piston/cylinder system, shown in Figure 2-6 and Figure 2-7, draws gas from the gas inlet system for delivery to the patient. See Section 2.5 for an integrated description of how the piston/cylinder works in conjunction with the electronics.

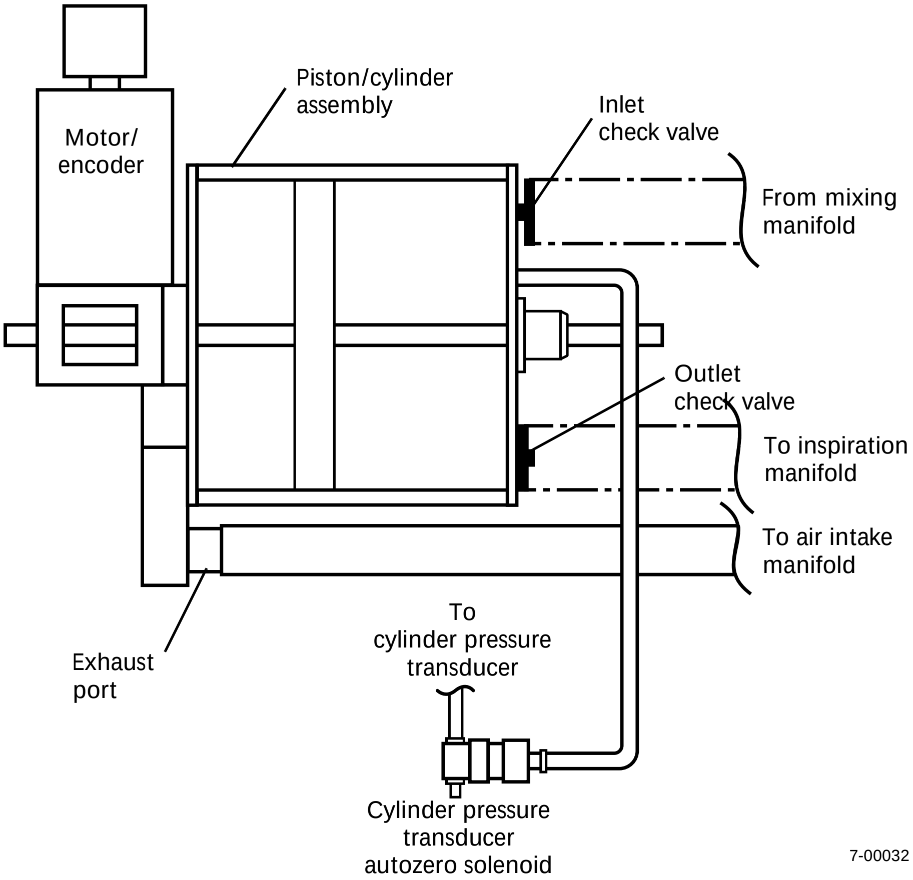

Piston/cylinder assembly
Inlet check valve
Motor/ encoder
From mixing manifold
Outlet check valve
To inspiration manifold
To air intake manifold
To cylinder pressure transducer
Exhaust port
Cylinder pressure transducer autozero solenoid
7-00032

Figure 2-6. Piston/cylinder system pneumatic diagram

2.2.2.1 Component descriptions

The piston/cylinder system includes the components described below; these are shown in Figure 2-7 and Figure 2-8.

- Gas is delivered to the patient by an aluminum **piston/cylinder**. The piston, inside a cylinder, moves backward and forward to draw in and expel gas. The piston/cylinder is connected via a rack and pinion to a **motor/encoder**. The motor moves the piston as directed by the electronics, while feedback from the encoder is used to monitor the piston's position.

  The piston is mounted on a shaft, which rides on precision linear bearings at each end of the cylinder. The shaft has a rack gear profile. It mates with a pinion gear attached to the motor shaft (Figure 2-9). When the motor speed and direction change, the piston also changes speed and direction. An interrupter flag located on the rack helps confirm piston position limits, in conjunction with two optoswitches. The piston/cylinder can deliver up to 2 L gas per breath.

  An important element of this piston-based pneumatic system is that no contact occurs between the piston and cylinder wall. The piston/cylinder has no seal;

instead, there is a minute gap of 50 ± 5 µm (0.002 in.) between the two. This gap is approximately the thickness of a thin sheet of paper.

Because the piston does not contact the cylinder, there is a continuous, measurable leak while the piston/cylinder is pressurized. To compensate for this "calibrated leak," the piston moves continuously within the cylinder. But, because the piston and cylinder have no contact, friction between the piston and cylinder is eliminated, resulting in reduced wear of piston/cylinder assembly parts, reduced electrical requirements, and enhanced responsiveness.

The piston/cylinder gap is maintained at all possible piston positions. Each new piston/cylinder assembly comes with several calibration constants that are specific to that particular assembly. These constants represent the gaps at various points corresponding to different piston positions. This data must be entered into NVRAM when a new assembly is installed.

- **Optoswitches** are read by the motor controller circuit for piston initialization purposes during POST and for fault detection purposes during ventilation. An optoswitch is closed when the rack flag breaks the infrared light beam (Figure 2-9).
- The **motor/encoder** is an FRU composed of an optical **encoder** attached to a brushless dc **motor**.

  The high-torque, direct-drive motor controls piston movement, under direction of the motor controller circuit on the controller PCB and the motor drive circuit on the BBU PCB. Three rotations of the motor shaft correspond to a 2.6 L volume displacement.

  The optical encoder, on top of the motor, along with the motor controller circuit (on the controller PCB), monitors the motor position (Figure 2-10). The optical encoder incorporates an emitter section, two codewheels, and a detector section. Each codewheel has a pattern photographically plated on it. As the motor shaft revolves, the codewheels rotate with respect to the emitter and photodetector sections, causing the light beam to be interrupted by the pattern of spaces and bars on the codewheels. The detectors are positioned such that a light period on one photodetector corresponds to a dark period on the other photodetector. The optical encoder was designed so that the final outputs from the two photodetectors (channels) are in quadrature with each other (90 degrees out of phase). Using the photodetector outputs, a decoder in the motor controller circuit tallies "quadcounts" and can determine the piston’s direction and speed.
- The **cylinder inlet** and **outlet check valves** are one-way valves located at the end of the piston/cylinder. The inlet check valve opens to let mixed gas fill the cylinder during piston retraction; it seals to prevent the cylinder contents from escaping through the gas inlet system during gas delivery. The outlet check valve lets gas exit the cylinder during gas delivery; it seals during piston retraction. The inlet check valve has a **translucent (clear)** leaf in a white housing, while the outlet check valve has a **translucent (clear)** leaf in an blue housing.
- The **cylinder pressure transducer** (on the pressure solenoid PCB), a gauge type, measures the cylinder pressure. The ventilator uses these cylinder pressure readings in various calculations, including cylinder leak, compliance compensation, during oxygen mixing, atmospheric pressure, and PEEP maintenance. The transducer is autozeroed via an autozero solenoid (see below).

- The **cylinder pressure transducer autozero solenoid** is a three-way valve. It autozeroes the transducer at power-on, once a minute for the first 10 minutes, and hourly thereafter. The transducer is autozeroed by venting to atmosphere. A muffler reduces the noise from the venting gas.

2.2.2.2 Operational description of piston/cylinder system

During piston retraction, the piston draws air and/or oxygen into the cylinder through the opened inlet check valve. The optical encoder (part of the motor/encoder) reports to the motor controller circuit the motor shaft position. The motor controller circuit, in turn, determines the piston position and velocity. The retraction velocity is controlled to draw in 150 L/min nominal. Gas behind the piston (mostly room air) is vented through the air intake filter to atmosphere.

During gas delivery, the motor drives the piston forward as required to meet the ventilator settings and patient effort. The gas flows through the opened outlet check valve and the inspiration manifold toward the patient.

At power on, POST verifies the piston's return, home, and full-stroke positions (Section 2.6.1). For a complete, sequential description of breath delivery, see Section 2.6.

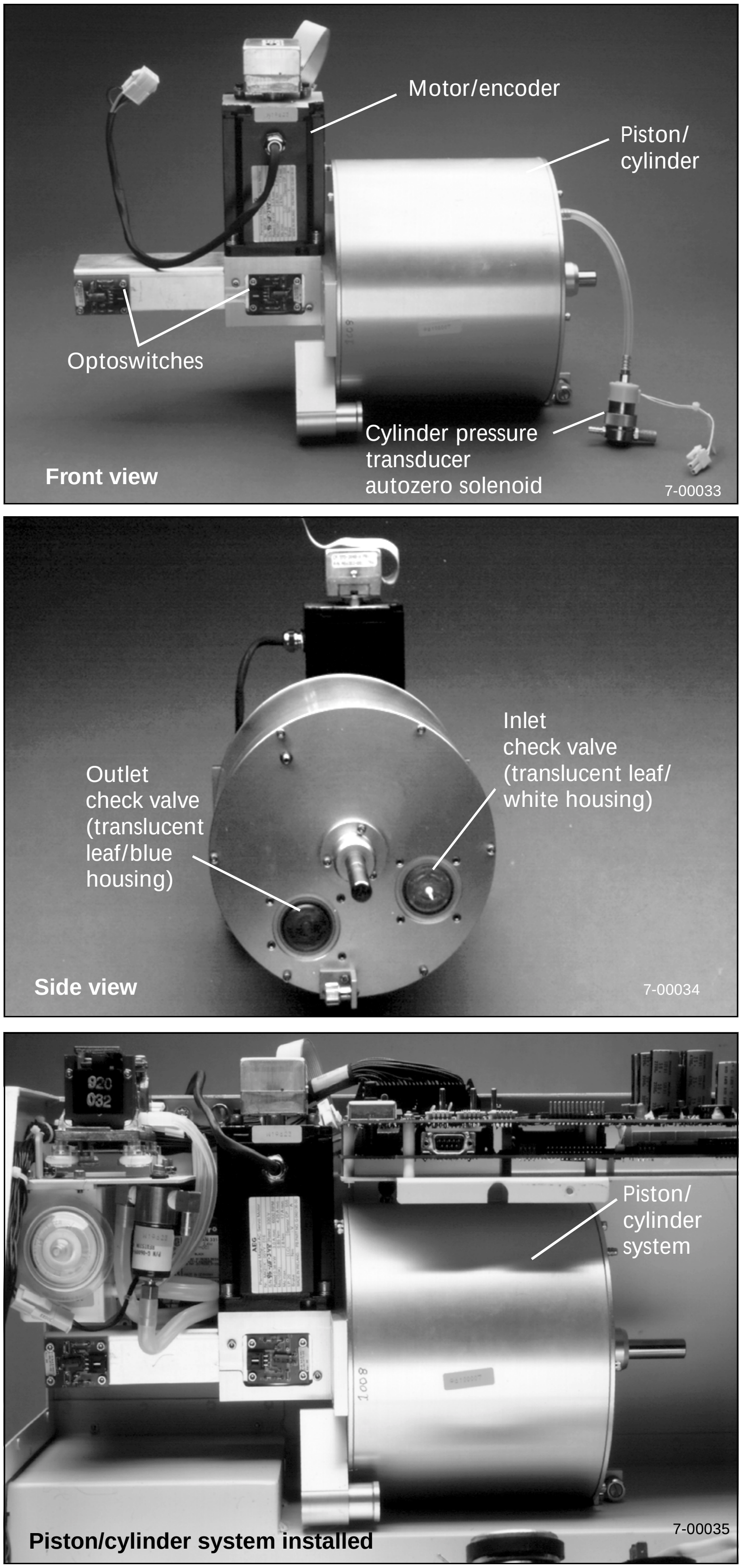

Motor/encoder
Piston/ cylinder
Optoswitches
Cylinder pressure transducer autozero solenoid
Front view
7-00033
Inlet check valve (translucent leaf/ white housing)
Outlet check valve (translucent leaf/blue housing)
Side view
7-00034
Piston/ cylinder system
Piston/cylinder system installed
7-00035

Figure 2-7. Piston/cylinder system

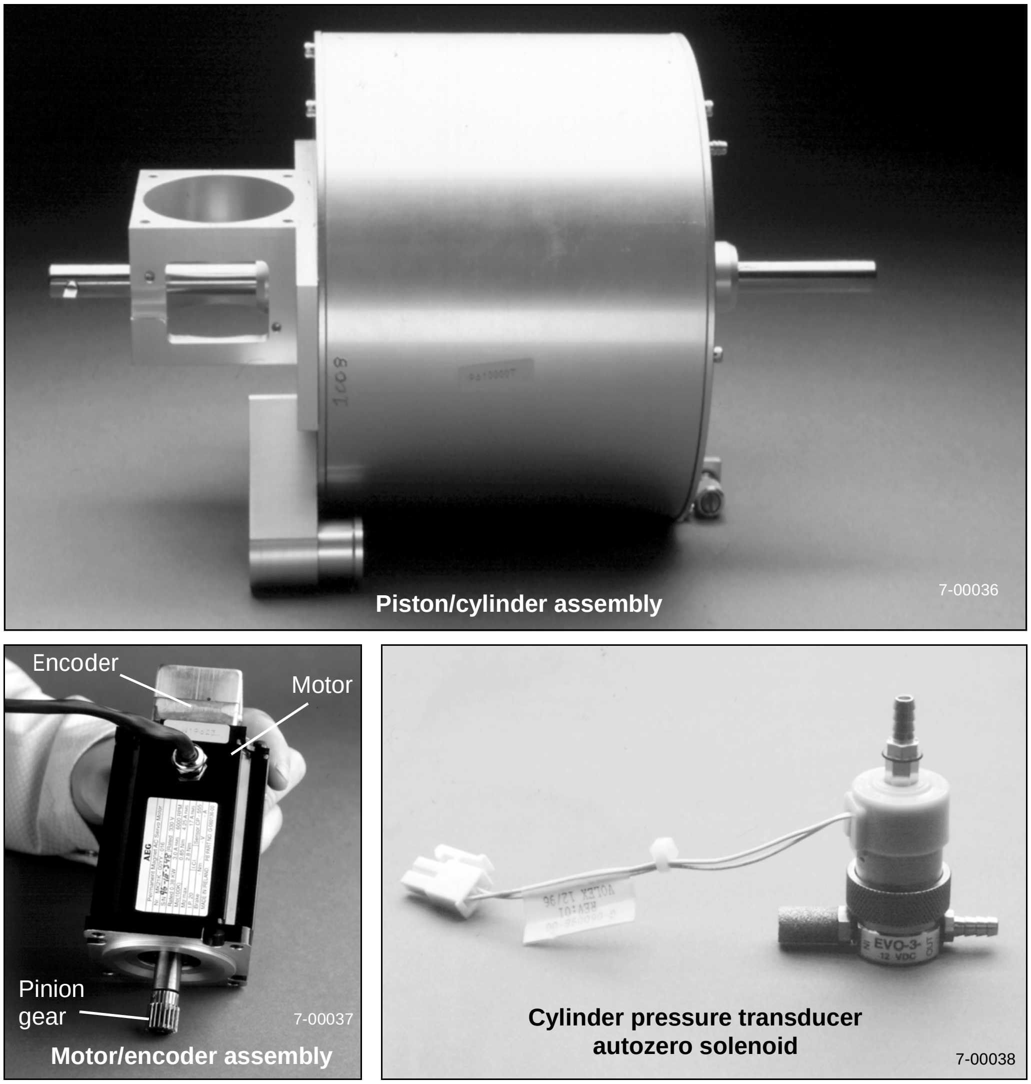
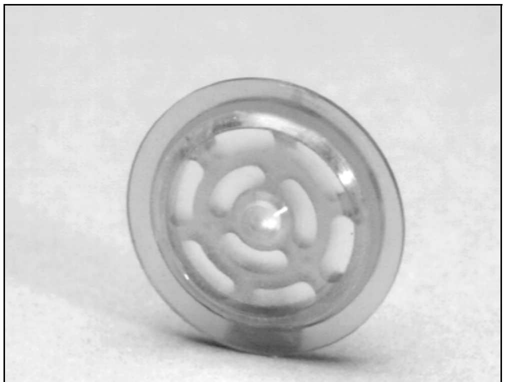

Piston/cylinder assembly
7-00036
Encoder
Motor
Pinion gear
7-00037
Motor/encoder assembly
Cylinder pressure transducer autozero solenoid
7-00038

Figure 2-8. Piston/cylinder system components (1 of 2)

Cylinder inlet check valve (white housing)

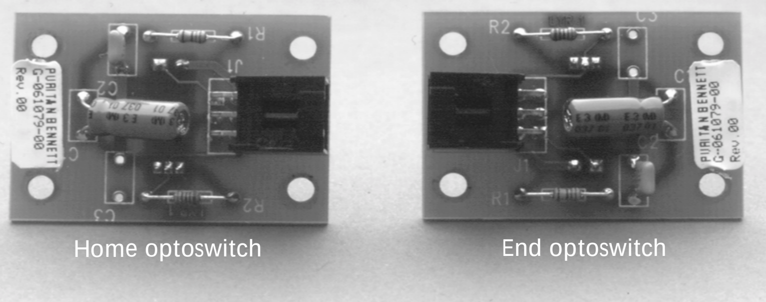
7-00039



Cylinder outlet check valve (blue housing)

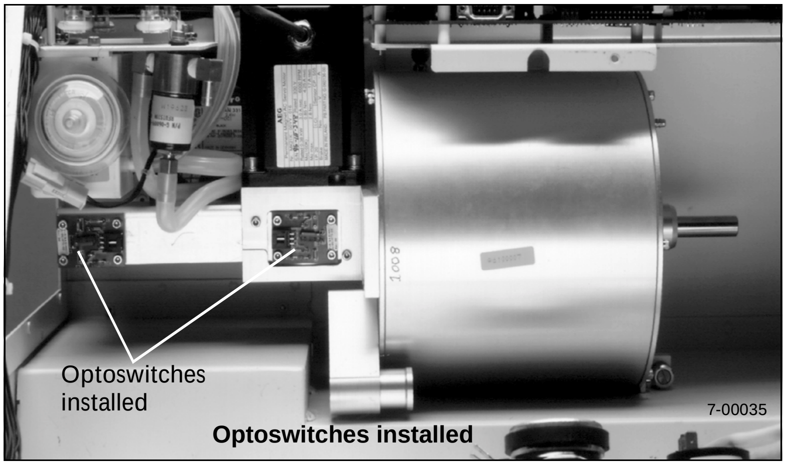
7-00040

NOTE: The home and end optoswitches are identical (P/N G-061255-00)


PURITAN BENNETT
G-061079-00
Rev. 00
R1
R2
C1
C2
C3
J1
Home optoswitch
End optoswitch

Optoswitches

7-00041


Optoswitches installed

7-00035

Optoswitches installed

Figure 2-8. Piston/cylinder system components (2 of 2)

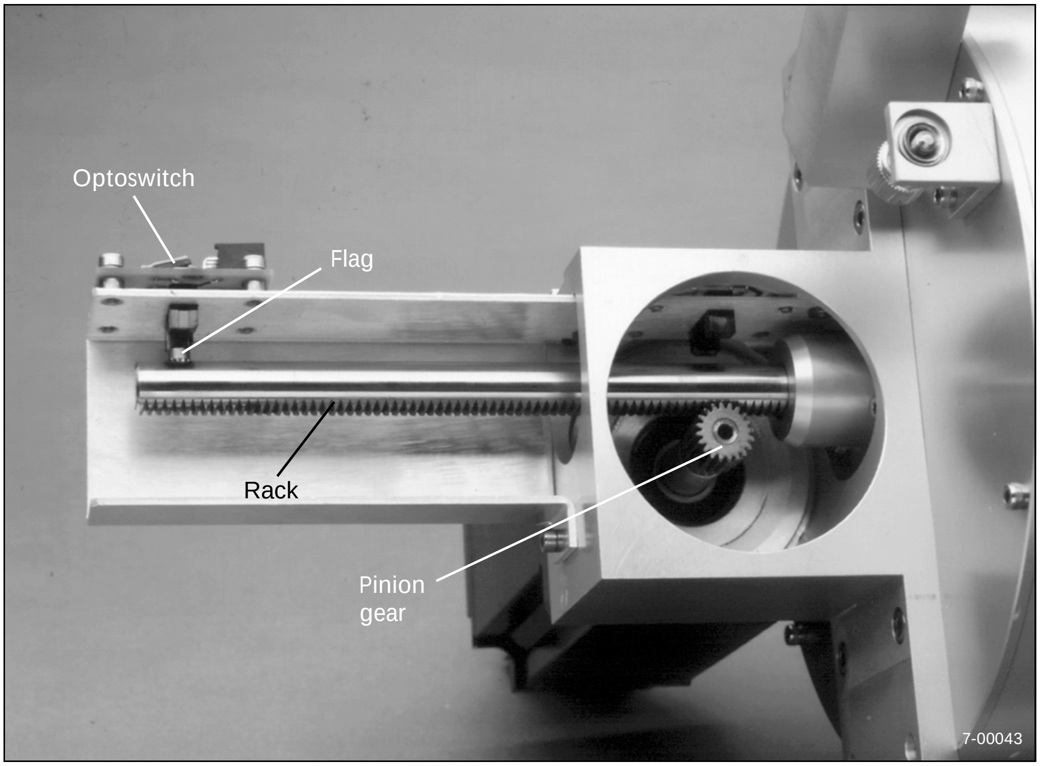

Optoswitch
Flag
Rack
Pinion gear
7-00043

Figure 2-9. Motor/encoder pinion gear and rack

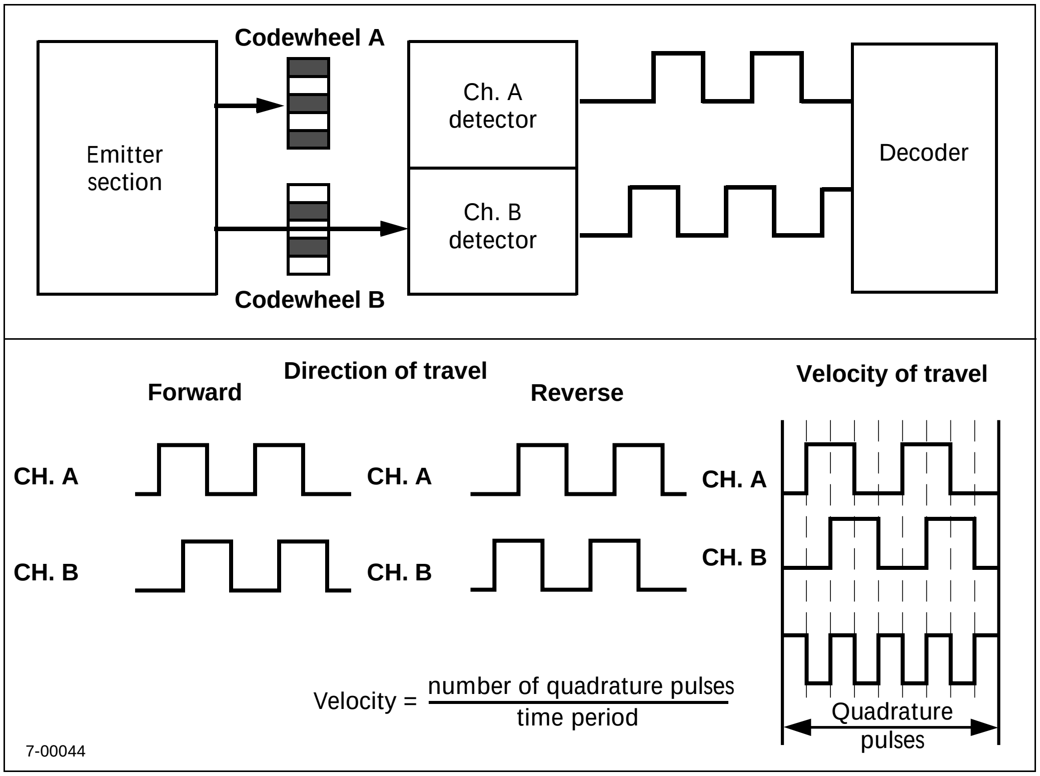

Codewheel A
Emitter section
Ch. A detector
Ch. B detector
Decoder
Codewheel B
Direction of travel
Forward
Reverse
Velocity of travel
CH. A
CH. B
CH. A
CH. B
CH. A
CH. B
Velocity = number of quadrature pulses / time period
Quadrature pulses
7-00044

Figure 2-10. Operation of optical encoder

2.2.3 Inspiration manifold system

The inspiration manifold system, shown in Figure 2-11 and Figure 2-12, provides a conduit between the cylinder and ventilator. It also senses the temperature and oxygen percentage of the delivered gas. It includes a safety valve to vent excessive pressure. It includes a pressure tap for the inspiration pressure transducer.

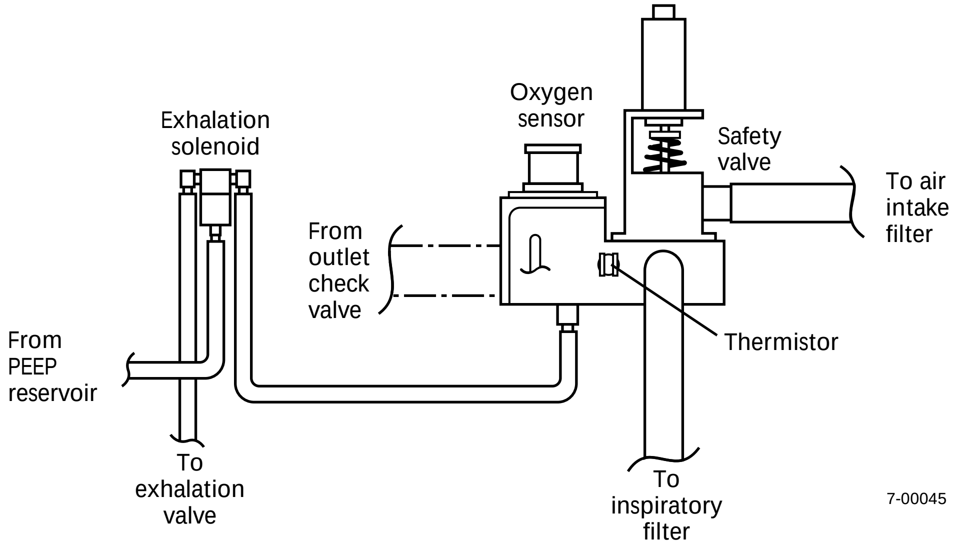


Figure 2-11. Inspiration manifold system pneumatic diagram

2.2.3.1 Component descriptions

The inspiration manifold system includes the components described below; these are shown in Figure 2-13.

- The **inspiration manifold** provides a conduit between the cylinder and ventilator outlet. A tap in the manifold connects to the inspiration pressure transducer (on the pressure solenoid PCB). The exhalation valve port permits pressure to be supplied to the exhalation valve (via the exhalation solenoid) during inspiration. The inspiration port permits gas delivery (through a silicone tube) to the ventilator outlet. The inspiration port incorporates a 22-mm ISO male conical connector for attachment of the inspiration filter and inspiration limb of the patient tubing system.
- The **oxygen sensor** is a galvanic sensor that measures the percentage of oxygen delivered from the cylinder. It produces a voltage proportional to the partial pressure of oxygen in the delivered gas. The sensor is accurate to ± 3% of the reading. For ventilators equipped with software revision H or later, the % O_2 is displayed if no alarm is active and the display of the oxygen sensor reading is enabled. The ventilator alarms if the sensed oxygen percentage is not within ± 10 percentage points of the setting.
- The **inspiration manifold thermistor** measures the inspiration gas temperature; this data is used in breath delivery calculations and oxygen percentage correction.

- The **inspiration pressure transducer** (on the pressure solenoid PCB), an absolute type, measures pressure at the inspiration manifold. When made with the safety valve open, this pressure reading is used to calculate atmospheric pressure. The calculated inspiration pressure value is a function of the inspiration pressure transducer reading minus the atmospheric pressure.
- The **exhalation (PEEP/CPAP) solenoid** is a three-way valve that selects the pneumatic source for piloting the exhalation valve. The solenoid is energized during all inspirations to provide exhalation valve pilot pressure via the inspiration manifold. When de-energized (during exhalation), the valve uses the pressure from the PEEP pump as its pilot source.
- The **safety valve** functions primarily to relieve overpressure in case of ventilator failure or an occlusion, and to allow patient breathing in case of total ventilator failure, such as complete loss of power. It has other functions; these are detailed in Section 2.8.3. The normally open valve is opened either under software control or via a dedicated circuit, as a backup.

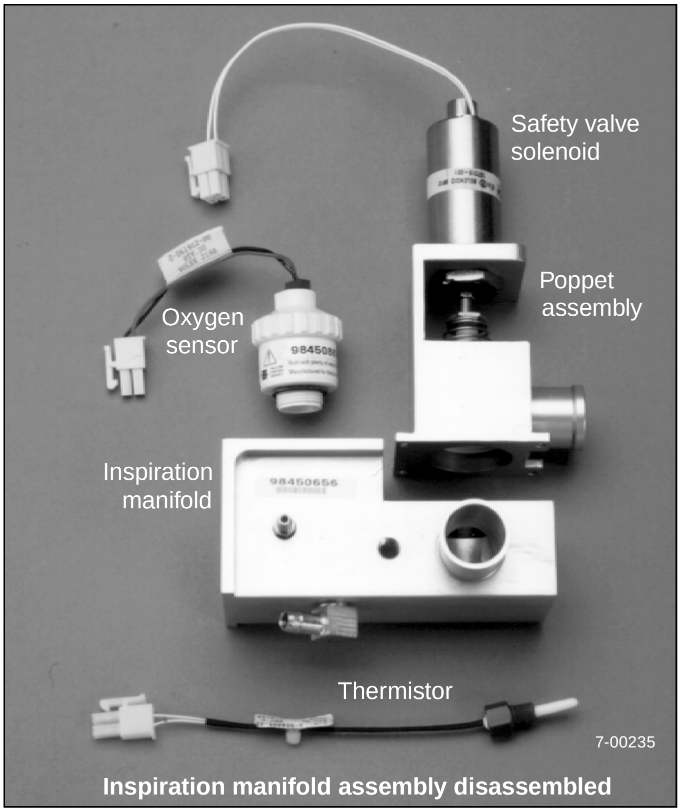
  The safety valve includes a solenoid actuator that is normally energized (closed) while the ventilator operates. The closed valve prevents gas from escaping to the room and thus allows the ventilator to deliver gas through the inspiration manifold to the patient. When the solenoid is de-energized, and the safety valve poppet lifts open via the return spring, opening the ventilator breathing circuit to atmosphere.

2.2.3.2 Operational description

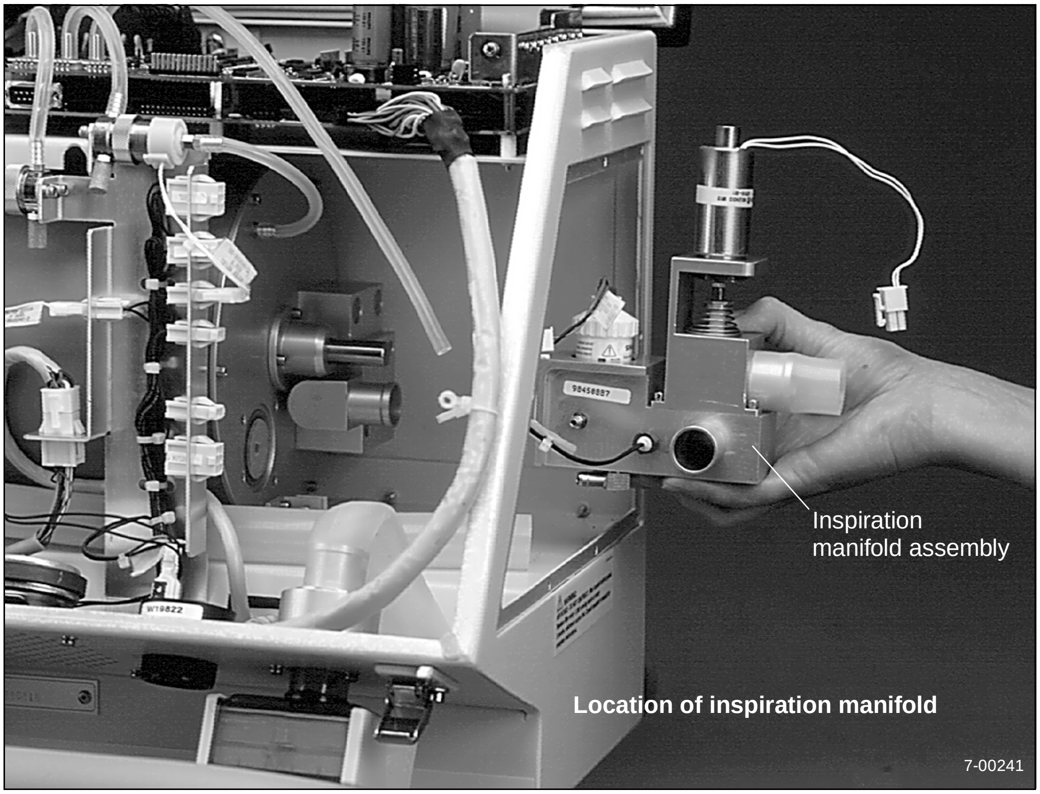
During the breath delivery phase, mixed gas from the cylinder flows through the inspiration manifold toward the patient. This inspiration gas also flows through the exhalation solenoid; this gas pressure pilots the exhalation valve closed during inspiration.

During exhalation, the exhalation solenoid routes PEEP pilot pressure to pilot the exhalation valve open as necessary to maintain PEEP.

If the software places the ventilator into the safety valve open (SVO) state (for example, if system pressure exceeds 92 cmH_2O) or if either the cylinder or patient pressure exceeds 115 cmH_2O, the safety valve solenoid is de-energized. The patient can then breathe room air. See Section 2.8 for a description of the SVO state.

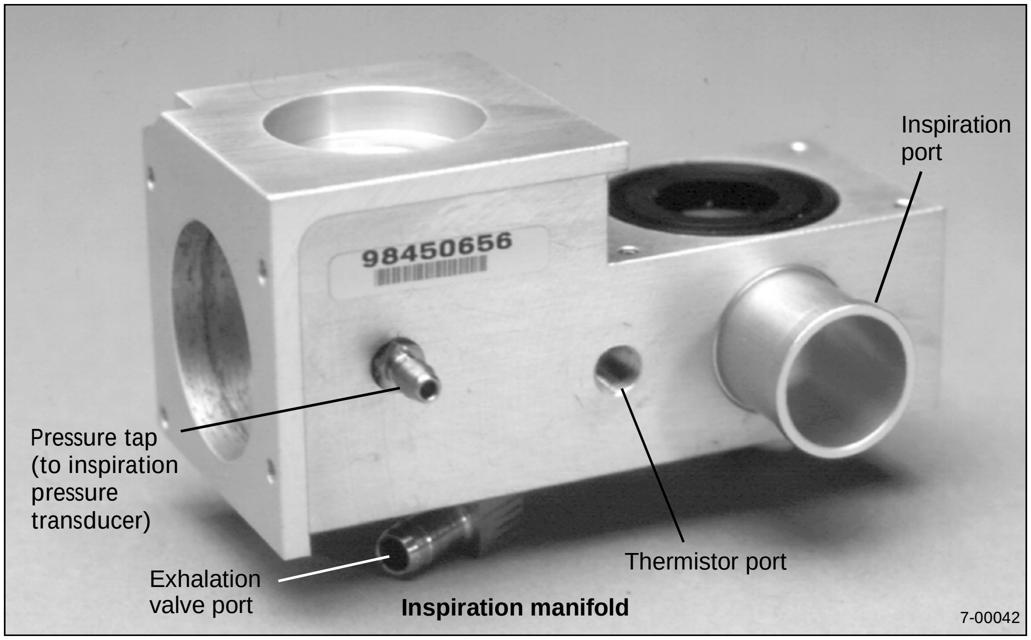

Safety valve solenoid
Poppet assembly
Oxygen sensor
Inspiration manifold
Thermistor
7-00235

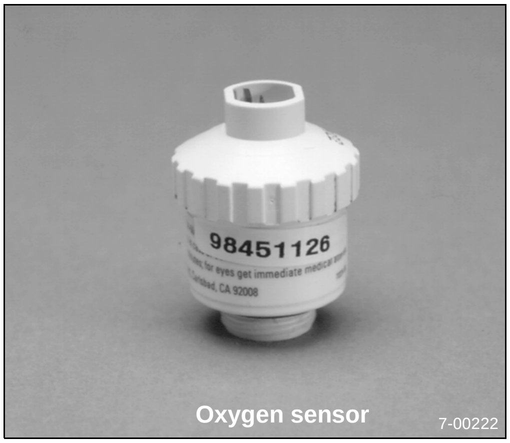
Inspiration manifold assembly disassembled

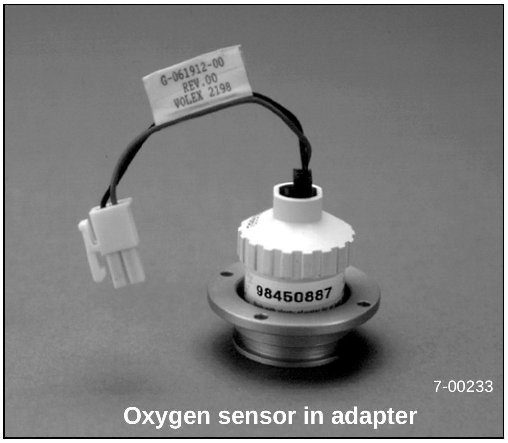

Inspiration manifold assembly
7-00241

Location of inspiration manifold

Figure 2-12. Inspiration manifold system


Inspiration port
98450656
Pressure tap (to inspiration pressure transducer)
Exhalation valve port
Thermistor port
Inspiration manifold
7-00042


98451126
Oxygen sensor
7-00222


G-061912-00 REV.00 VOLEX 2198
98450887
7-00233
Oxygen sensor in adapter

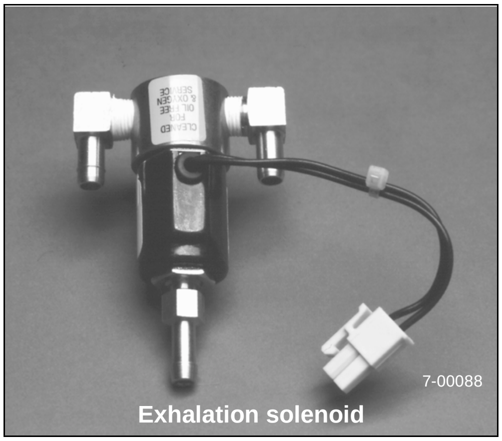

7-00088
Exhalation solenoid

Figure 2-13. Inspiration manifold system components (1 of 2)

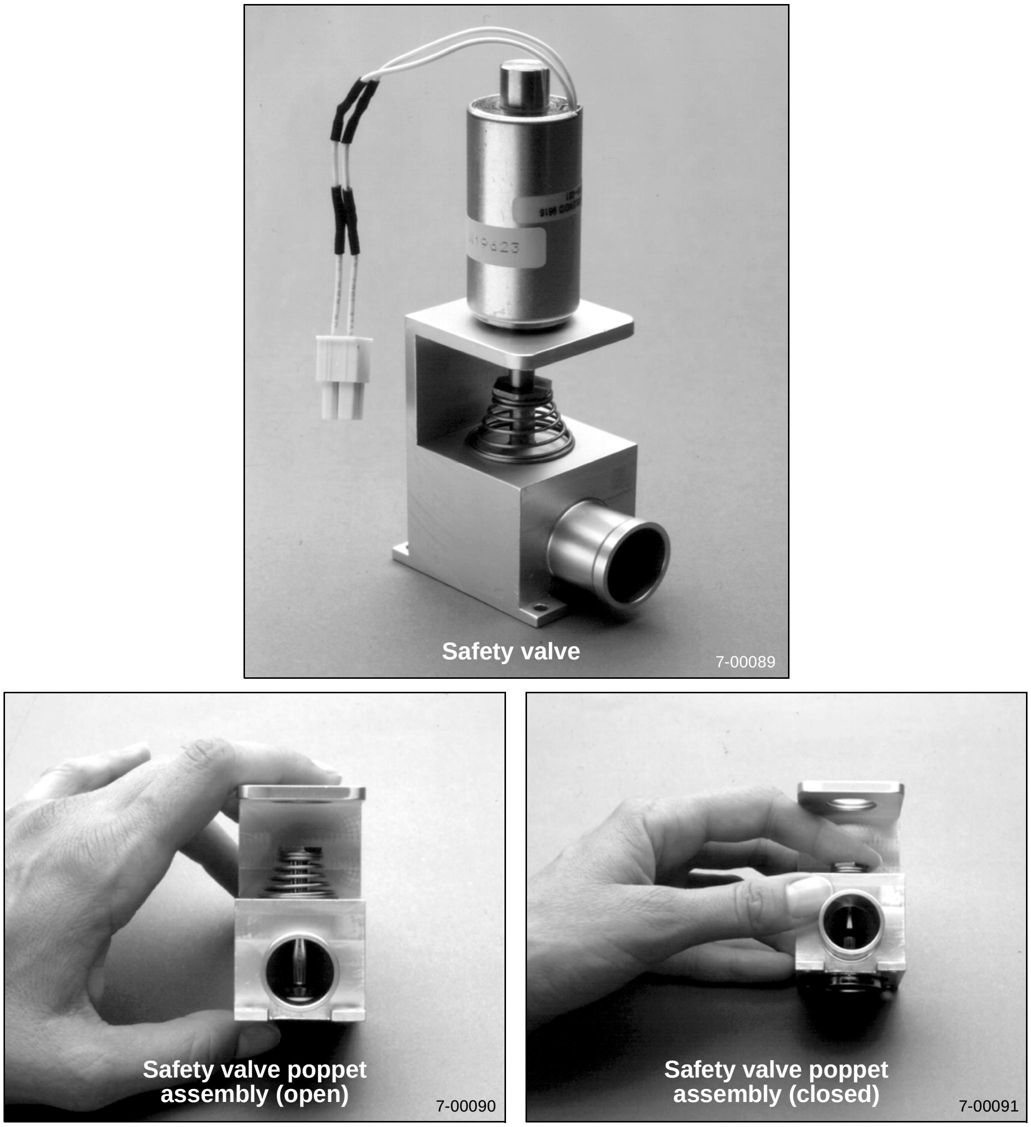

Safety valve
7-00089
Safety valve poppet assembly (open)
7-00090
Safety valve poppet assembly (closed)
7-00091

Figure 2-13. Inspiration manifold system components (2 of 2)

2.2.4 Patient system

The patient system, shown in Figure 2-14, includes those "external" components that carry gas from the ventilator to the patient, control patient ventilation, and isolate the ventilator from the patient with bacteria filters. The patient system also heats and humidifies delivered gas if a humidification device is installed.

The patient system includes the components described below; these are shown in Figure 2-15. For information on the patient tubing circuits offered by Nellcor Puritan Bennett, consult the product catalog.

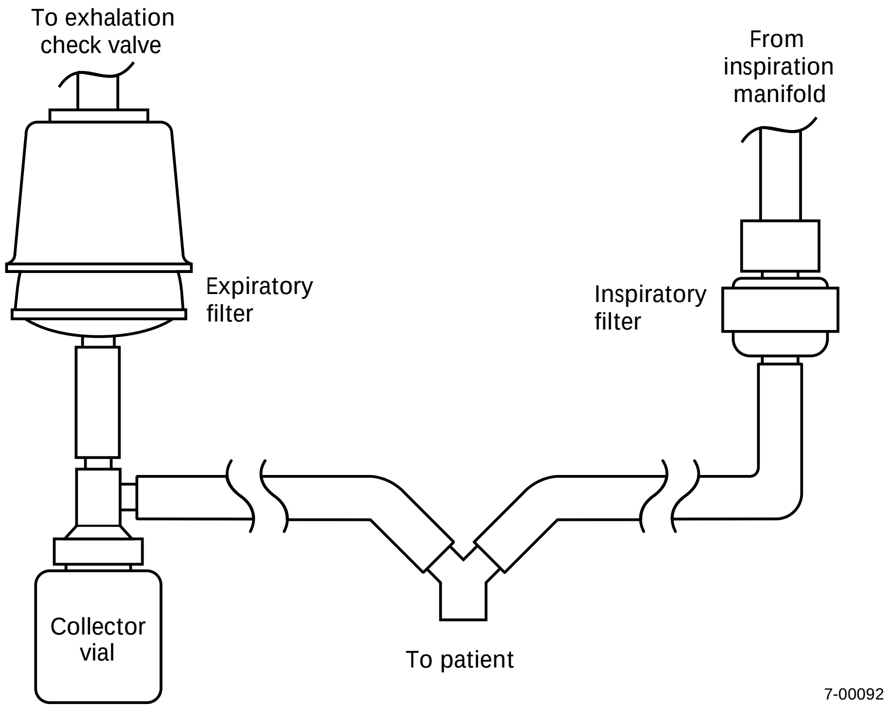


Figure 2-14. Patient system pneumatic diagram

- The **inspiratory** (main flow) **filter** (the Nellcor Puritan Bennett D/Flex or Re/Flex Filter) helps protect the patient from contamination by the gas supplies, and helps protect the ventilator from contamination by the patient system. The filter captures particles of 0.3 µm nominal and larger at a flow of 100 L/min with 99.97% efficiency. It has 22-mm ISO conical connections.
- The **ventilator breathing circuit** provides a conduit for gas flowing between the ventilator and patient. It is composed of two smooth-bore "flex" tubes, the inspiration and exhalation tubes. The inspiration tube carries gas from the ventilator to the patient, while the exhalation tube carries exhaled gas from the patient to the ventilator.
- The **humidification device** moistens the gas delivered to the patient so it more closely approximates gas inspired through the nasal passages.
- The **collector vial** collects moisture in the exhaled gas to help keep water out of the exhalation system, in particular the expiratory filter.
- The **expiratory filter** helps prevent bacteria in the patient’s exhaled gas from being vented to room air and reduces cross-contamination of the ventilator. The filter captures particles of 0.3 µm nominal and larger at a flow of 100 L/min with 99.97% efficiency. It has 22-mm ISO conical connections.

  Exhaled gas flows in through the filter’s center, then through the hydrophobic paper toward the filter’s sides, and out the filter outlet. Liquid water drains into the collector vial.

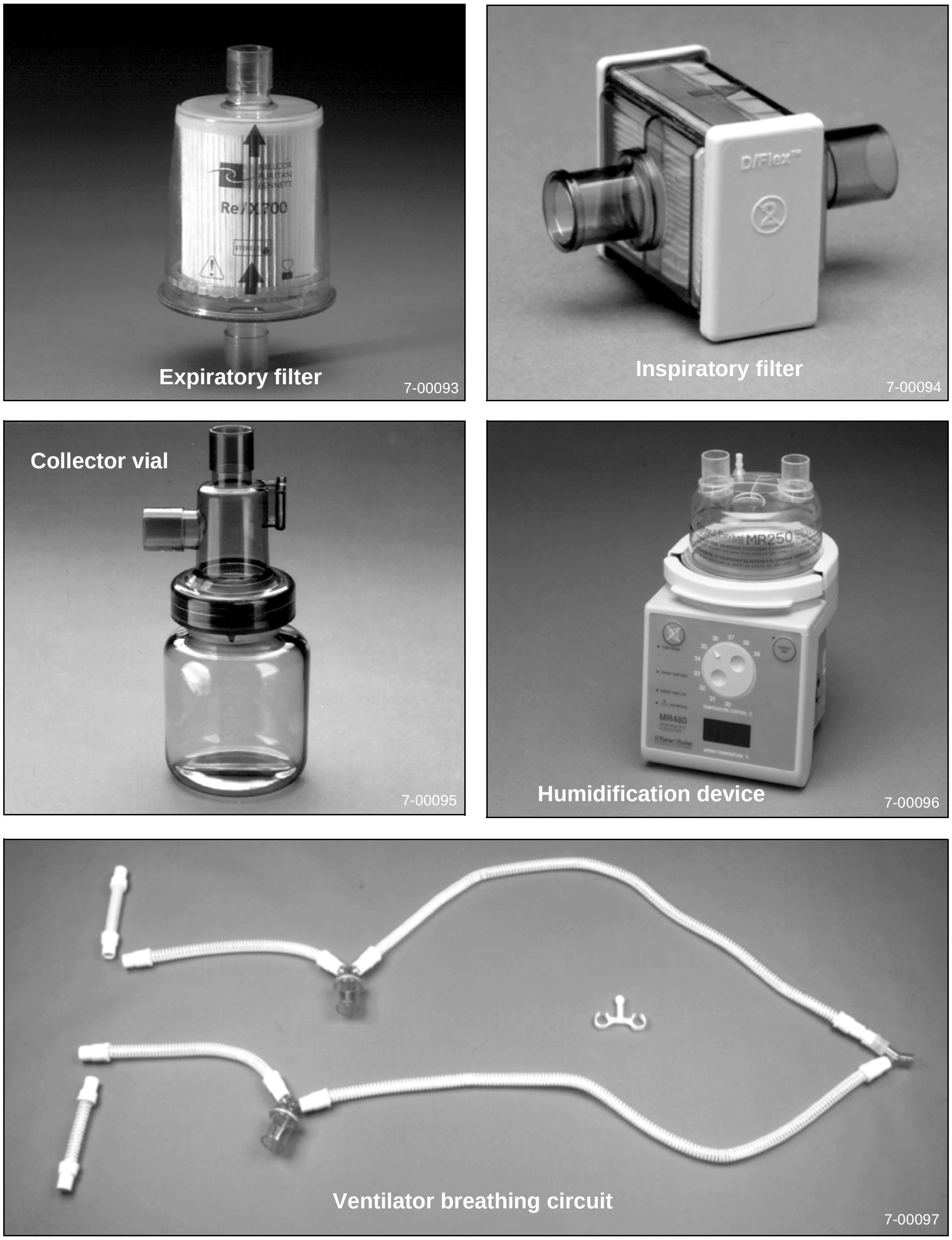

Expiratory filter
7-00093
Inspiratory filter
7-00094
Collector vial
7-00095
Humidification device
7-00096
Ventilator breathing circuit
7-00097

Figure 2-15. Patient system components

2.2.5 Exhalation system

The exhalation system, shown in Figure 2-16 and Figure 2-17, controls and monitors the flow of the patient's exhaled gas.

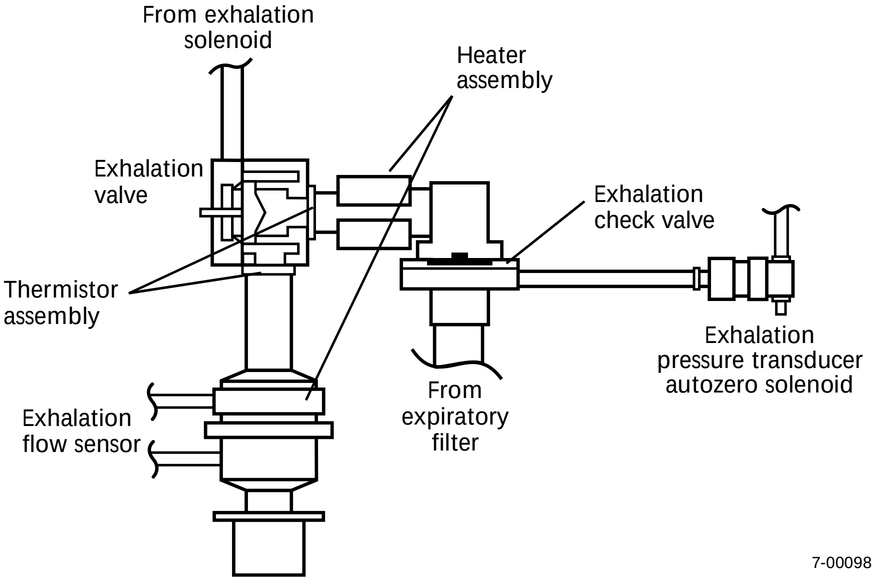

From exhalation solenoid
Heater assembly
Exhalation valve
Exhalation check valve
Thermistor assembly
Exhalation pressure transducer autozero solenoid
Exhalation flow sensor
From expiratory filter
7-00098

Figure 2-16. Exhalation system pneumatic diagram

2.2.5.1 Component descriptions

The exhalation assembly includes these components; these are shown in Figure 2-18.

- The **expiratory filter housing** retains the expiratory filter.
- The **exhalation check valve** is a one-way device that prevents the patient from rebreathing exhaled gas. It is opened by the pressure of exhaled gas, resulting in exhaled gas flowing through the exhalation system. When the patient stops exhaling, the valve closes.
- The **exhalation pressure transducer** (on the pressure solenoid PCB), a gauge type, measures the exhalation system pressure. The ventilator uses these exhalation pressure readings in its breath delivery calculations. The transducer is autozeroed via an autozero solenoid (see below).
- The **exhalation pressure transducer autozero solenoid** is a two-way valve. It autozeroes the transducer at power-on, once a minute for the first 10 minutes, and hourly thereafter. The transducer is autozeroed by venting to atmosphere. A muffler reduces noise and filters the venting gas.
- The blanket-type **exhalation heater assembly** contains two 10 W heaters that wrap around exhalation system tubing. One is located just before the exhalation valve. The other is located at the exhalation flow sensor. The heaters maintain the temperature of the exhalation assembly above the condensation point to prevent "rain-out" in the exhalation assembly.

- The **exhalation thermistor assembly** provides the electronics with temperature feedback. An analog circuit regulates the current to the heater assembly accordingly to maintain the heater at 50 °C, thereby eliminating condensation during exhalation. Feedback from one thermistor, which is in contact with the cross tube heater, is used to control the temperature to both heaters. The second thermistor, which is in contact with the exhalation flow sensor housing, provides a backup to monitor the heater temperature.
- The **exhalation valve assembly**, a pneumatically actuated valve, closes during inspiration to prevent delivered gas from venting to the atmosphere. During exhalation, it opens sufficiently to maintain the operator-selected PEEP. The exhalation valve is piloted by the exhalation solenoid (in the PEEP system). The valve has an area ratio of 1.4:1. For example, if the PEEP system provides a pilot pressure of 10 cmH_2O, then the patient must produce a pressure of 14 cmH_2O to open the valve. At circuit pressures below PEEP, the valve remains closed; at pressures higher than PEEP, the valve is opened.
- The **exhalation flow sensor** provides flow information on a patient's exhaled gas. The sensor is actually a fine mesh screen with pressure taps on both sides. The pressure taps connect to a differential pressure transducer on the pressure solenoid PCB. Because the flow across the screen is proportional to the pressure drop across it, the electronics can use these pressure measurements to determine exhaled flow.
- The **exhalation flow sensor pressure transducer** (on the pressure solenoid PCB), a differential type, monitors the exhaled flow. The transducer works in conjunction with the exhalation flow sensor, described above.

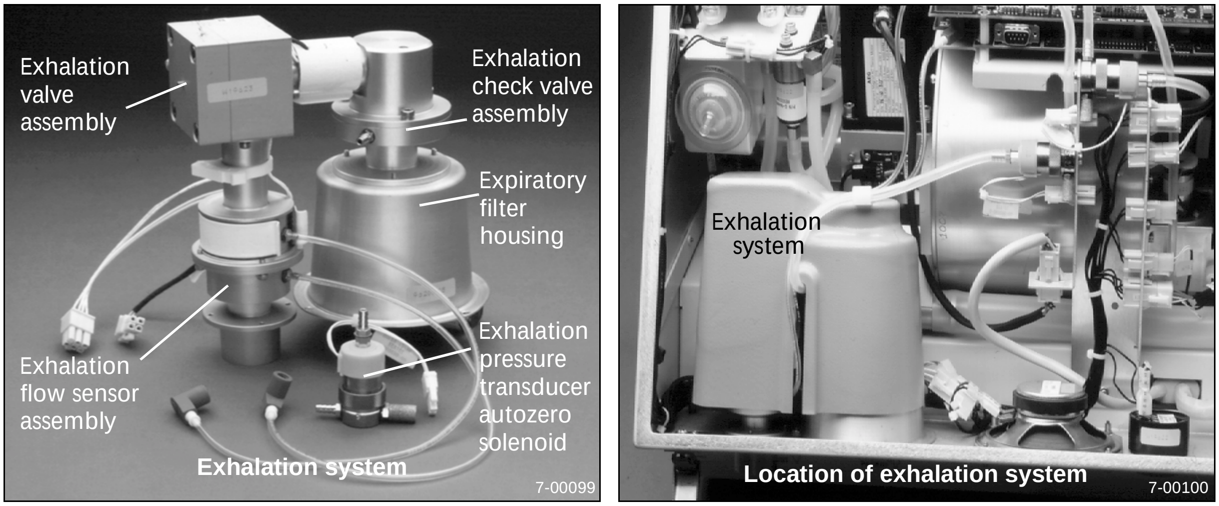
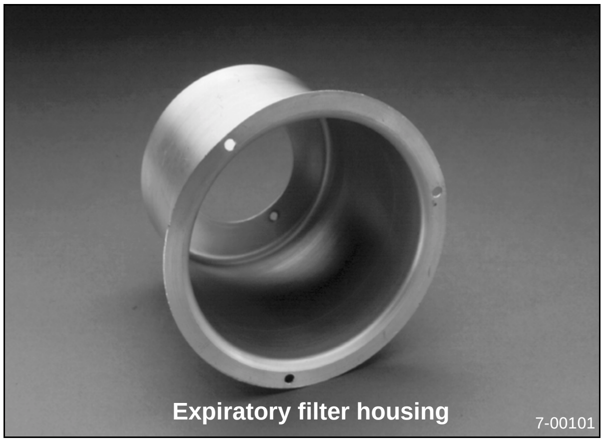
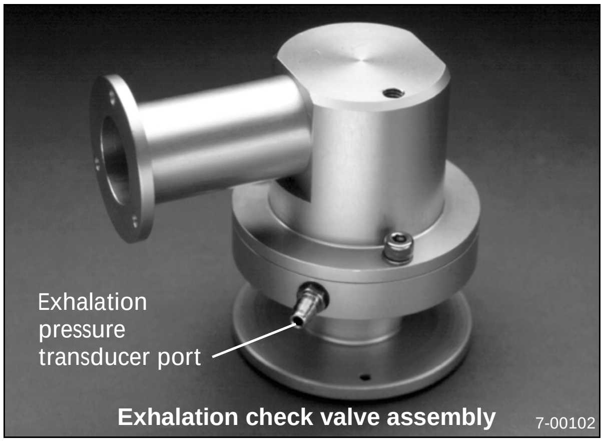
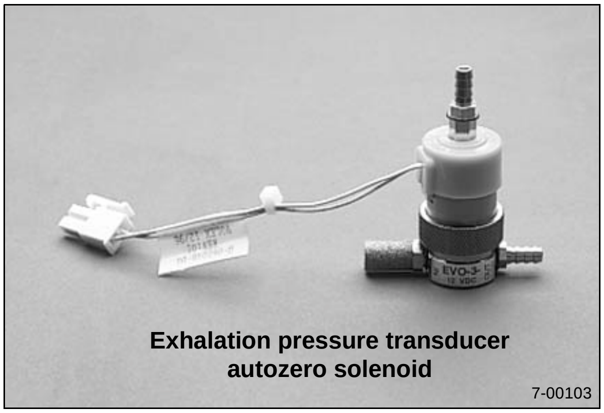
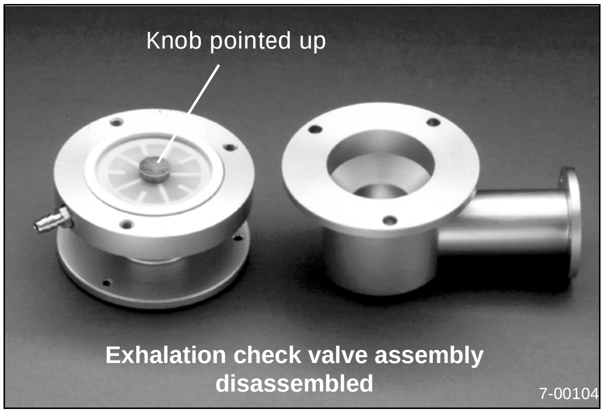

Exhalation valve assembly
Exhalation check valve assembly
Expiratory filter housing
Exhalation flow sensor assembly
Exhalation pressure transducer autozero solenoid
Exhalation system
7-00099
Exhalation system
Location of exhalation system
7-00100

Figure 2-17. Exhalation system


Expiratory filter housing


Exhalation check valve assembly
Exhalation pressure transducer port
7-00102


Exhalation pressure transducer autozero solenoid
EVO-3-
12 VDC
7-00103


Exhalation check valve assembly disassembled
Knob pointed up
7-00104

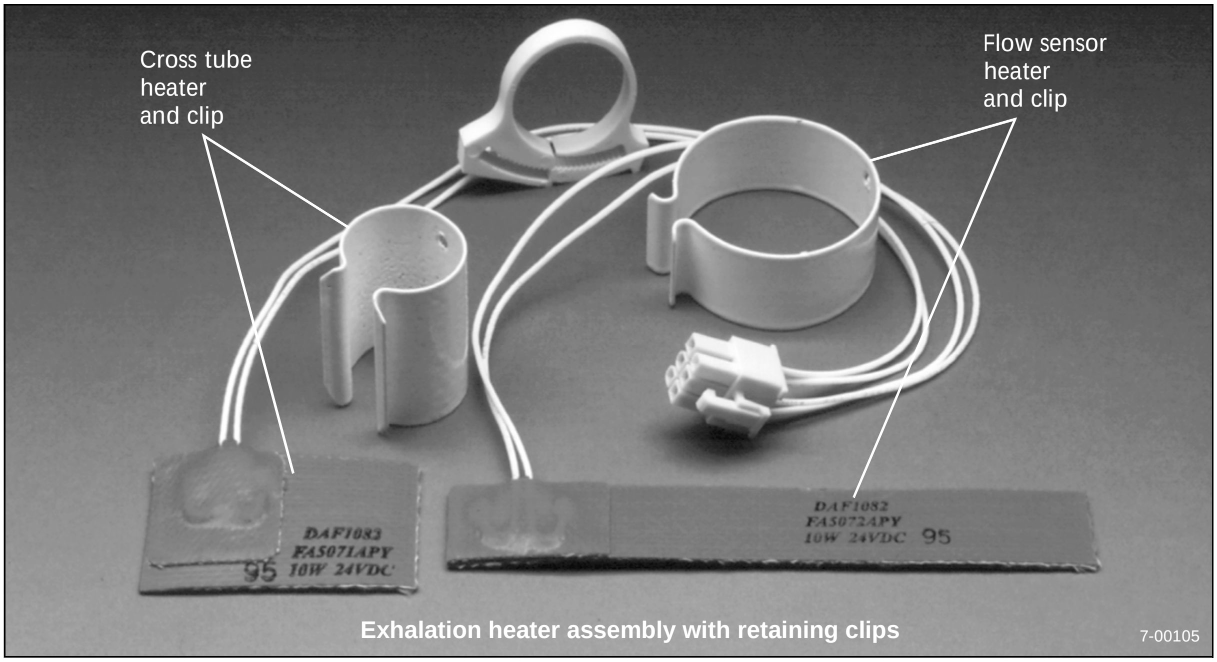
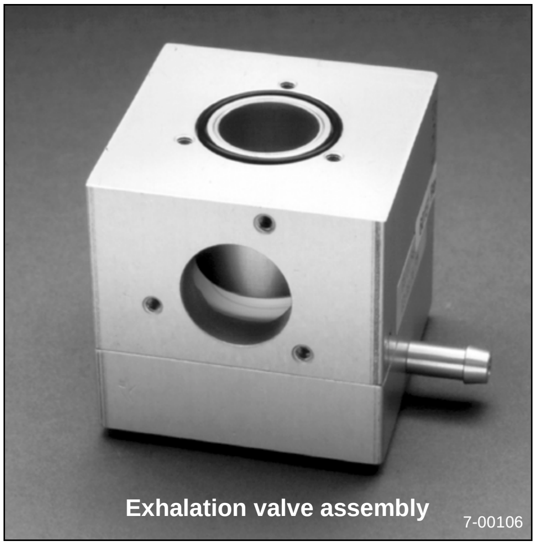
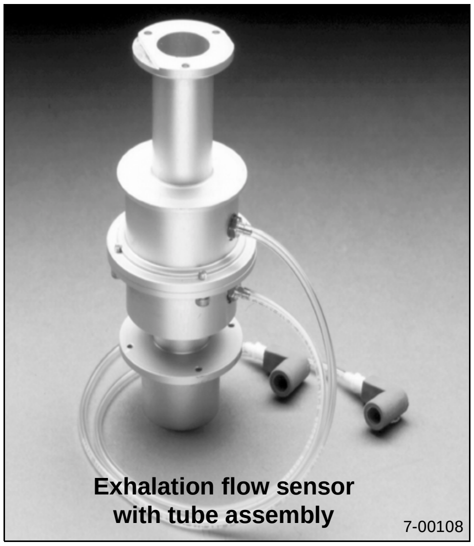

Exhalation heater assembly with retaining clips
Cross tube heater and clip
Flow sensor heater and clip
DAF1083
FA5071APY
10W 24VDC
95
DAF1082
FA5072APY
10W 24VDC
95
7-00105

Figure 2-18. Exhalation system components (1 of 2)


Exhalation valve assembly


Exhalation flow sensor with tube assembly

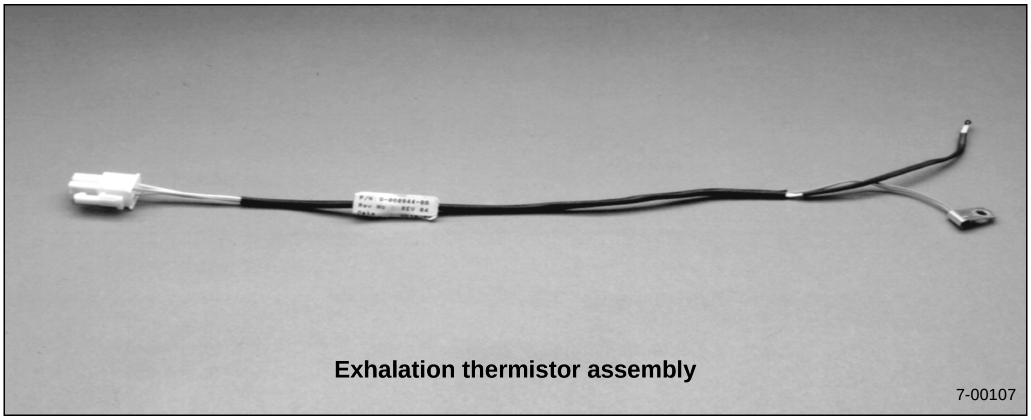

Exhalation thermistor assembly

Figure 2-18. Exhalation system components (2 of 2)

2.2.5.2 Operational description

During exhalation, patient gas enters the exhalation system through the expiratory filter. The pressure of the exhaled gas causes the check valve to open. The gas then flows toward the opened exhalation valve. (The valve was opened by the exhalation solenoid, sufficiently to maintain the operator-selected PEEP.) The exhaled gas flows through the opened valve and is vented through the ventilator outlet.

Heaters heat the exhalation assembly walls to minimize moisture in the assembly, while thermistors provide the ventilator with temperature feedback. The exhalation flow sensor and pressure transducer provide readings used in breath delivery calculations.

2.2.6 PEEP/CPAP system

The PEEP/CPAP system, shown in Figure 2-19 and Figure 2-20, regulates pressure to the exhalation valve as required to maintain PEEP/CPAP during exhalation.

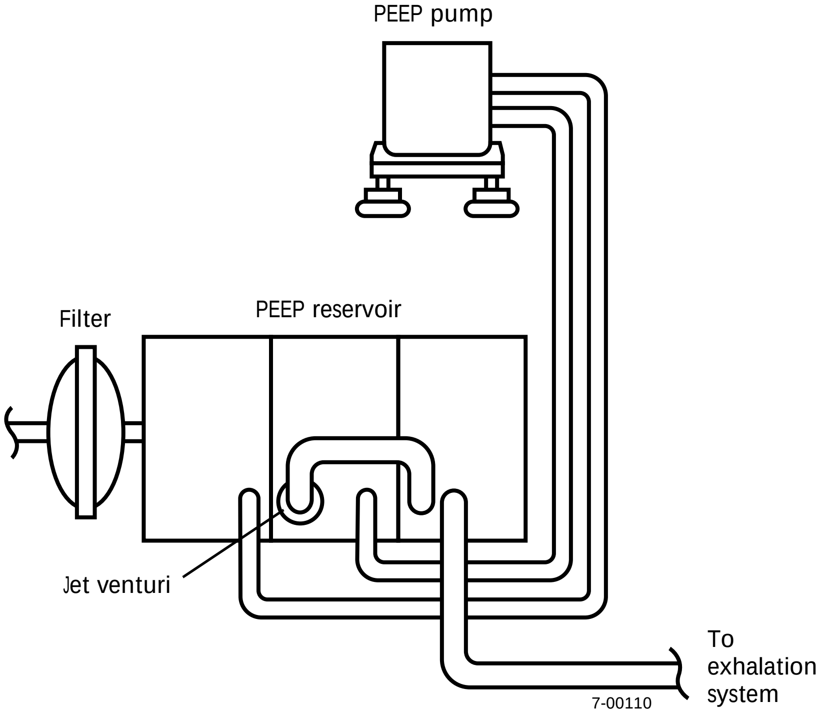


Figure 2-19. PEEP/CPAP system pneumatic diagram

2.2.6.1 Component descriptions

The PEEP/CPAP system includes these components; these are shown in Figure 2-21.

- The **filter** removes particles of 0.3 µm nominal from the air to be compressed by the PEEP pump.
- The **PEEP reservoir** has three chambers. Air is drawn into the chamber 1, and from there into the PEEP pump. This chamber reduces pump noise. Air compressed by the pump is then forced into chamber 2, which reduces pressure fluctuations. Air exits chamber 2 through a jet venturi, which drops the pressure to the desired PEEP/CPAP pilot pressure. Chamber 3 acts like a capacitor, reducing pressure fluctuations and preventing PEEP undershoot.
- The **PEEP pump**, a vibrating-armature pump, generates PEEP/CPAP pilot pressure. Gas compressed by the PEEP pump fills a reservoir. The pump is controlled by pulse-width modulating the pump drive voltage.

2.2.6.2 System operation

If PEEP is selected, the pump is turned on, drawing room air through the filter, into the reservoir, and toward the pump. The pump compresses the air as required to supply PEEP requirements. The compressed gas is then drawn into a separate chamber of the reservoir. This gas exits through a jet venturi, which reduces the pressure to the desired PEEP/CPAP pilot pressure. It then enters a final chamber, which provides further damping of pressure oscillations. During exhalation, the gas flows through the de-energized exhalation solenoid, which pilots the exhalation valve open as required. During inspiration, the pump remains on, but the exhalation valve is piloted by the inspiratory pressure, not PEEP pilot pressure.

Feedback from the exhalation pressure transducer helps the ventilator maintain the PEEP/CPAP at the selected value. Even with a ventilator breathing circuit leak of up to 10 L/min, PEEP/CPAP can be maintained. The ventilator compensates by adjusting the piston/cylinder output.

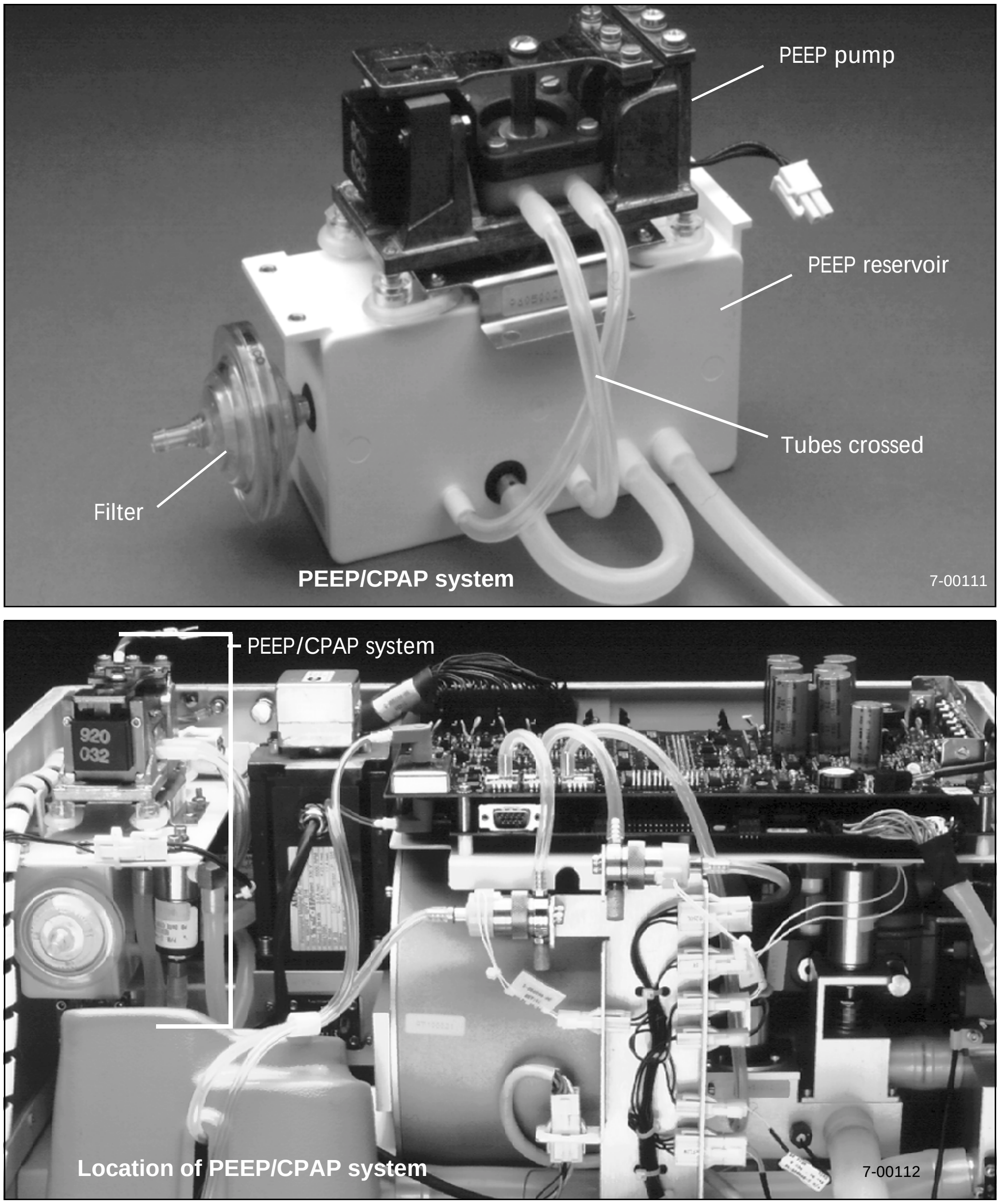

PEEP pump
PEEP reservoir
Tubes crossed
Filter
PEEP/CPAP system
7-00111
PEEP/CPAP system
Location of PEEP/CPAP system
7-00112

Figure 2-20. PEEP/CPAP system

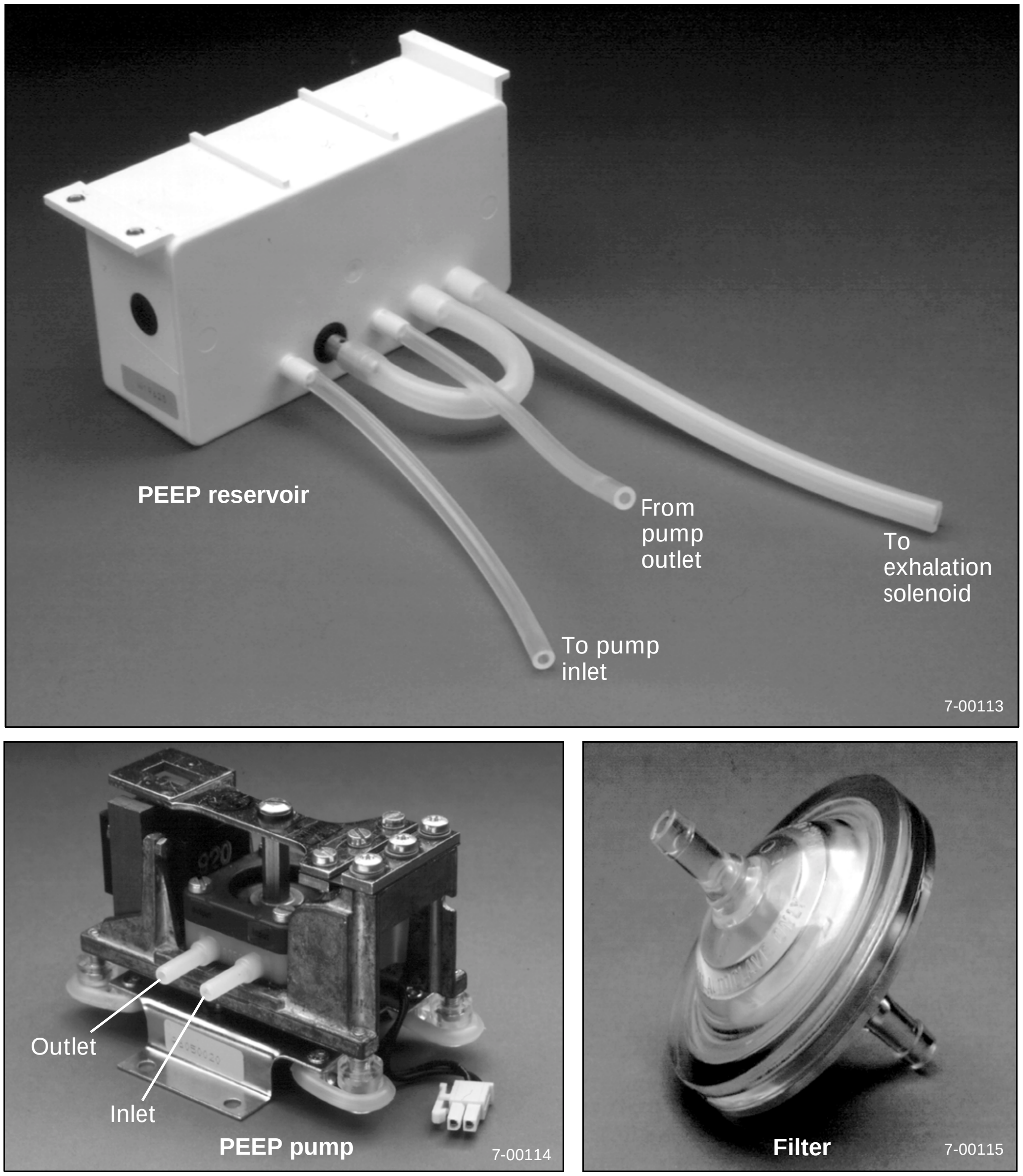

PEEP reservoir
From pump outlet
To exhalation solenoid
To pump inlet
7-00113
Outlet
Inlet
PEEP pump
7-00114
Filter
7-00115

Figure 2-21. PEEP/CPAP system components

2.3 Electrical system

The *700 Series Ventilator System* electrical system includes the following:

- Power assembly, including power input components, the power supply, the battery backup (BBU) PCB, and the power assembly fan
- Internal battery
- External battery
- Pressure solenoid PCB
- Controller PCB
- User interface, including the user interface PCB, the keyboard, and the knob/encoder
- Miscellaneous parts including the speaker, piezo alarm, main fan, air flow thermistor assembly, and air intake manifold sensor
- Communications option assembly if the Communicatons option is installed in the ventilator

The ventilator head harness (Figure 2-22) interconnects many of these parts. Interrelationship of components is illustrated in Figure 2-23. For a discussion of electropneumatic parts, or electrical parts used in close conjunction with pneumatic parts, see Section 2.2. For wiring details, see Figure 2-24.

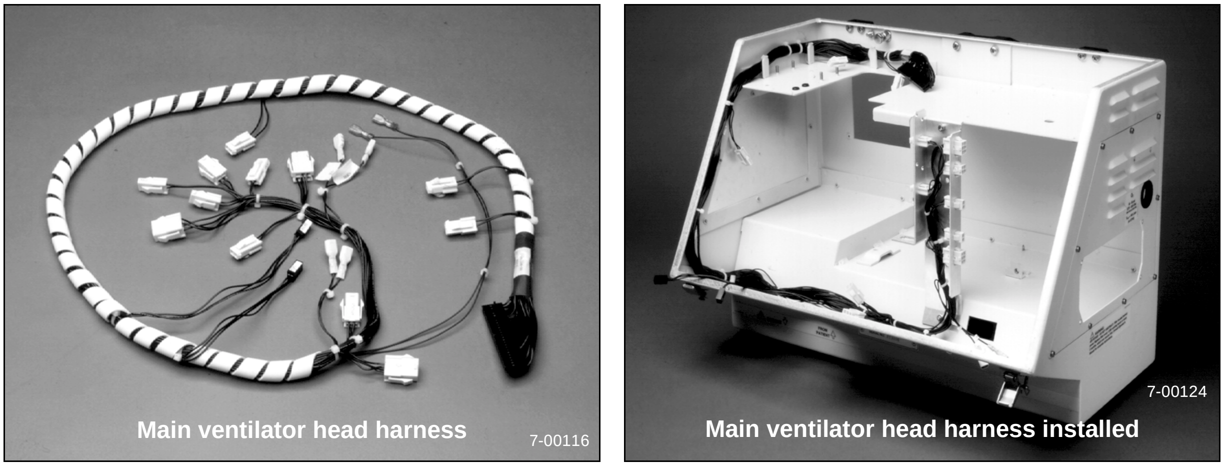

Main ventilator head harness
7-00116
7-00124
Main ventilator head harness installed

Figure 2-22. Main ventilator head harness

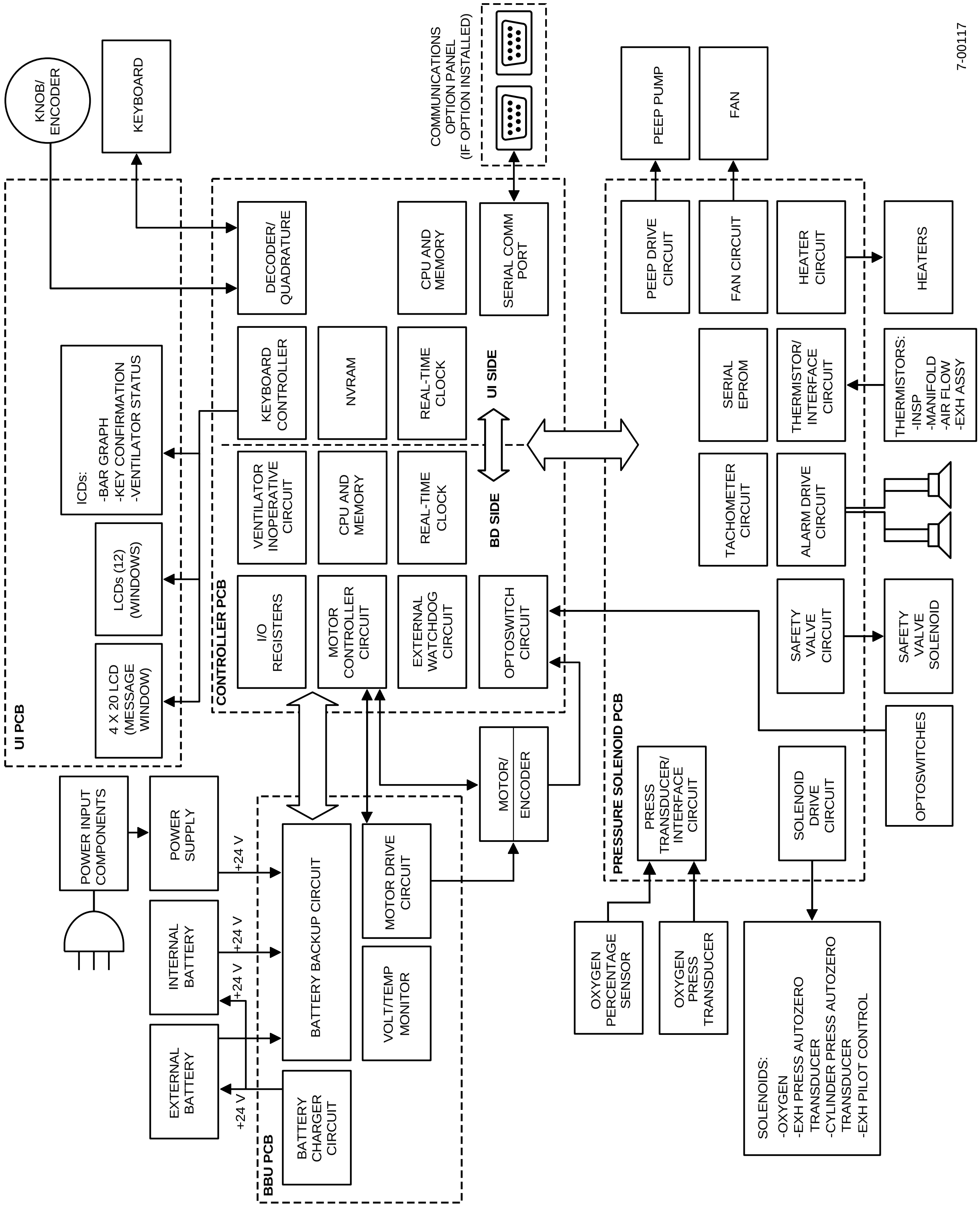

UI PCB
KNOB/ ENCODER
4 X 20 LCD (MESSAGE WINDOW)
LCDs (12) (WINDOWS)
ICDs:
-BAR GRAPH
-KEY CONFIRMATION
-VENTILATOR STATUS
KEYBOARD
POWER INPUT COMPONENTS
EXTERNAL BATTERY
INTERNAL BATTERY
POWER SUPPLY
+24 V
+24 V
+24 V
+24 V
BBU PCB
BATTERY CHARGER CIRCUIT
BATTERY BACKUP CIRCUIT
VOLT/TEMP MONITOR
MOTOR DRIVE CIRCUIT
CONTROLLER PCB
I/O REGISTERS
VENTILATOR INOPERATIVE CIRCUIT
KEYBOARD CONTROLLER
DECODER/ QUADRATURE
MOTOR CONTROLLER CIRCUIT
CPU AND MEMORY
NVRAM
EXTERNAL WATCHDOG CIRCUIT
REAL-TIME CLOCK
REAL-TIME CLOCK
CPU AND MEMORY
COMMUNICATIONS OPTION PANEL (IF OPTION INSTALLED)
MOTOR/ ENCODER
OPTOSWITCH CIRCUIT
BD SIDE
UI SIDE
SERIAL COMM PORT
OXYGEN PERCENTAGE SENSOR
OXYGEN PRESS TRANSDUCER
PRESSURE SOLENOID PCB
PRESS TRANSDUCER/ INTERFACE CIRCUIT
PEEP DRIVE CIRCUIT
PEEP PUMP
TACHOMETER CIRCUIT
SERIAL EPROM
FAN CIRCUIT
FAN
SOLENOIDS:
-OXYGEN
-EXH PRESS AUTOZERO TRANSDUCER
-CYLINDER PRESS AUTOZERO TRANSDUCER
-EXH PILOT CONTROL
SOLENOID DRIVE CIRCUIT
SAFETY VALVE CIRCUIT
ALARM DRIVE CIRCUIT
THERMISTOR/ INTERFACE CIRCUIT
HEATER CIRCUIT
OPTOSWITCHES
SAFETY VALVE SOLENOID
THERMISTORS:
-INSP
-MANIFOLD
-AIR FLOW
-EXH ASSY
HEATERS
7-00117

Figure 2-23. *700 Series Ventilator System* block diagram

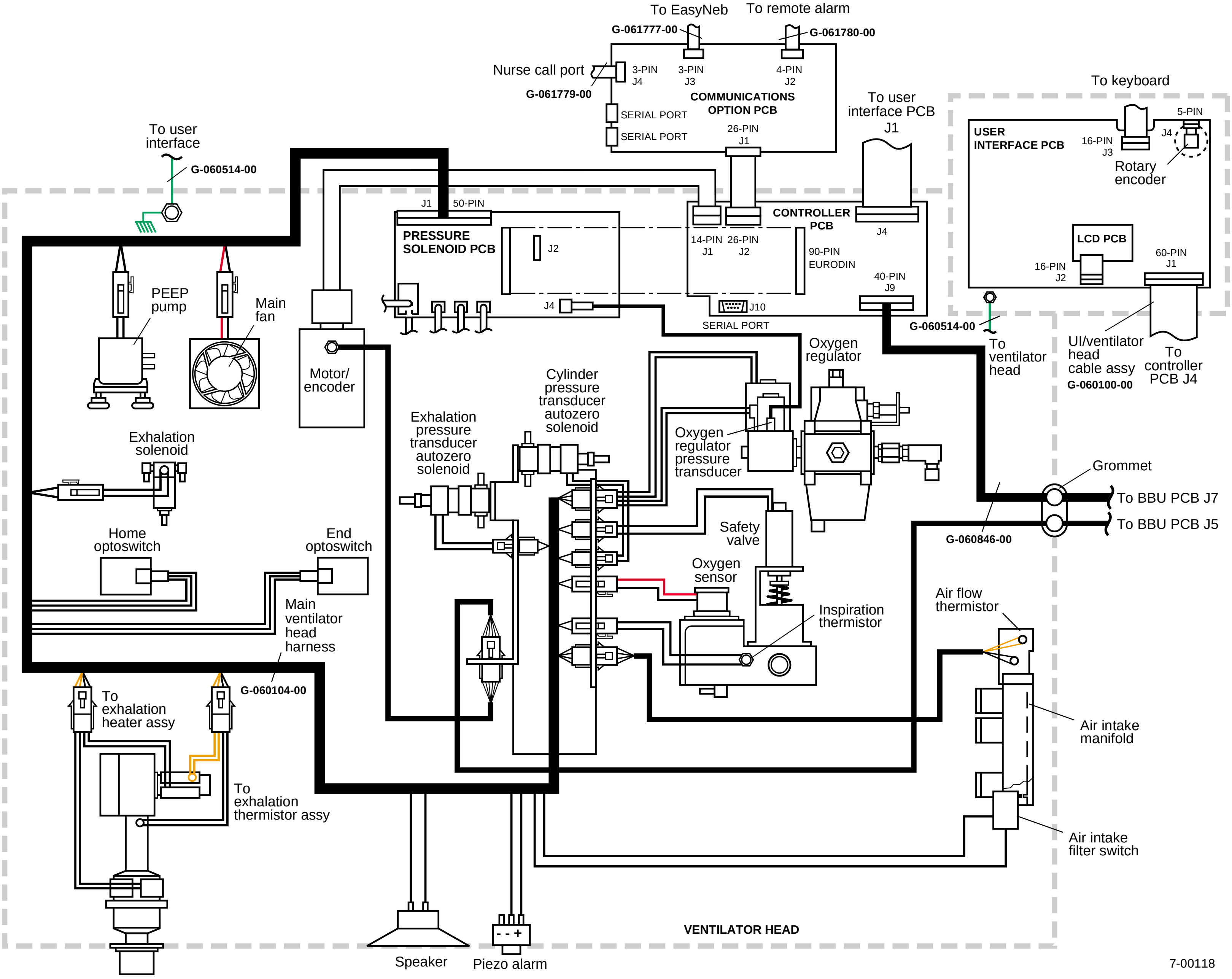

To EasyNeb
To remote alarm
G-061777-00
G-061780-00
Nurse call port
G-061779-00
3-PIN J4
3-PIN J3
4-PIN J2
COMMUNICATIONS OPTION PCB
SERIAL PORT
SERIAL PORT
26-PIN J1
To user interface PCB J1
To keyboard
USER INTERFACE PCB
16-PIN J3
5-PIN J4
Rotary encoder
LCD PCB
16-PIN J2
60-PIN J1
To user interface
G-060514-00
J1
50-PIN
PRESSURE SOLENOID PCB
J2
J4
CONTROLLER PCB
14-PIN J1
26-PIN J2
90-PIN EURODIN
J4
40-PIN J9
J10
SERIAL PORT
G-060514-00
To ventilator head
UI/ventilator head cable assy
G-060100-00
To controller PCB J4
PEEP pump
Main fan
Motor/ encoder
Exhalation pressure transducer autozero solenoid
Cylinder pressure transducer autozero solenoid
Oxygen regulator
Oxygen regulator pressure transducer
Exhalation solenoid
Grommet
To BBU PCB J7
To BBU PCB J5
G-060846-00
Safety valve
Oxygen sensor
Home optoswitch
End optoswitch
Main ventilator head harness
Inspiration thermistor
Air flow thermistor
G-060104-00
To exhalation heater assy
Air intake manifold
To exhalation thermistor assy
Air intake filter switch
- - +
Speaker
Piezo alarm
VENTILATOR HEAD
7-00118

Figure 2-24. Wiring diagram (1 of 2)

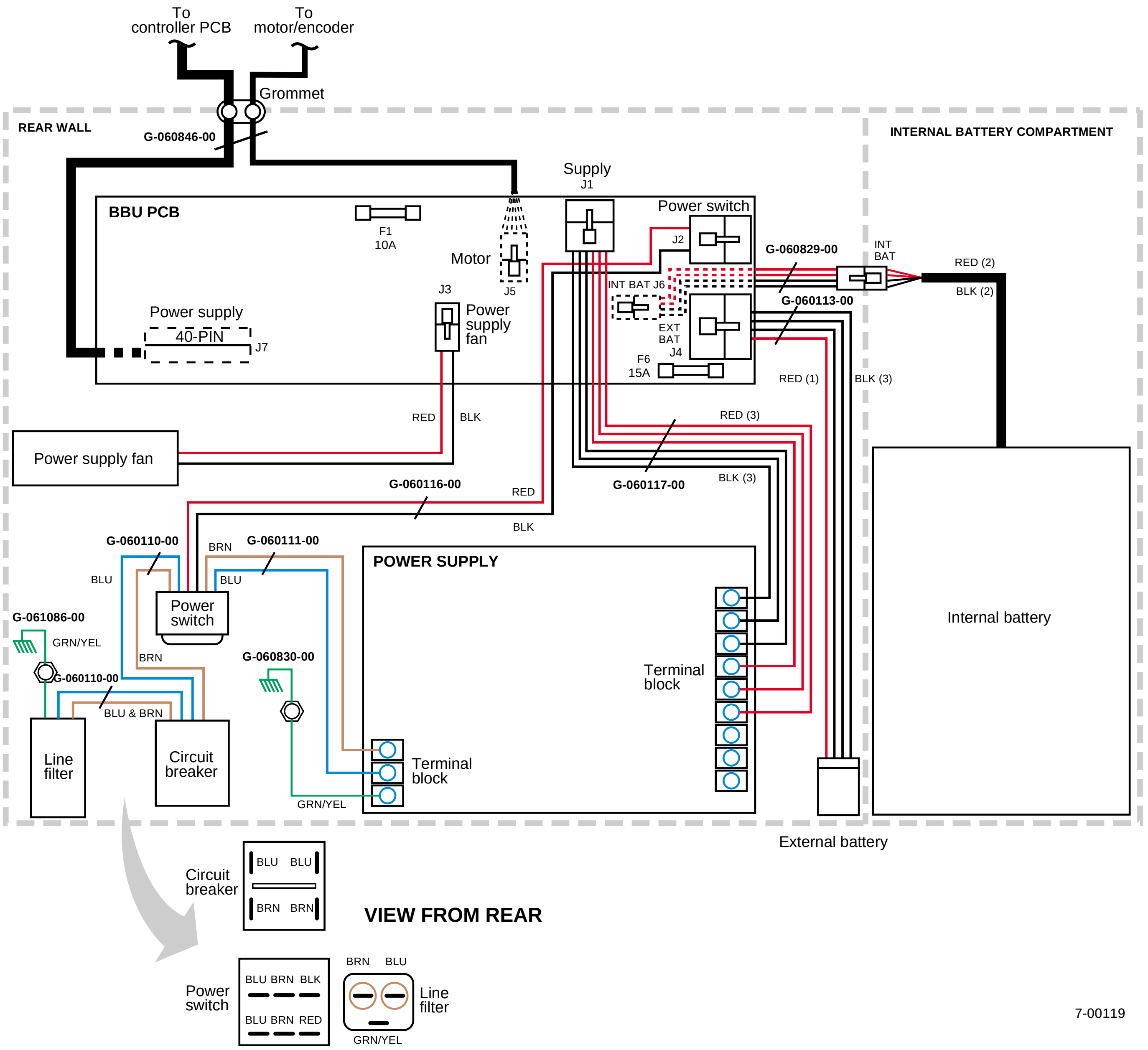
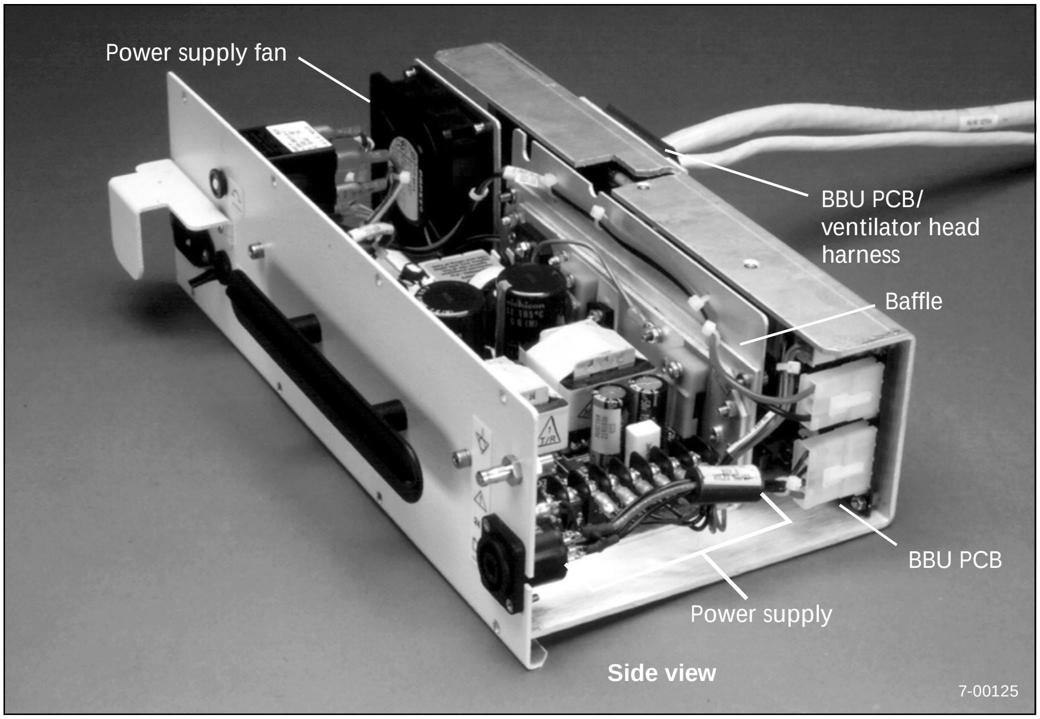

To
controller PCB
To
motor/encoder
Grommet
REAR WALL
G-060846-00
INTERNAL BATTERY COMPARTMENT
BBU PCB
F1
10A
Supply
J1
Power switch
J2
Motor
J5
J3
Power supply
40-PIN
J7
Power
supply
fan
INT BAT J6
EXT
BAT
J4
F6
15A
G-060829-00
G-060113-00
INT
BAT
RED (2)
BLK (2)
RED (1)
BLK (3)
RED
BLK
Power supply fan
RED (3)
G-060116-00
RED
G-060117-00
BLK (3)
BLK
G-060110-00
BRN
G-060111-00
POWER SUPPLY
BLU
BLU
Power
switch
G-061086-00
GRN/YEL
BRN
G-060830-00
G-060110-00
BLU & BRN
Terminal
block
Line
filter
Circuit
breaker
Terminal
block
GRN/YEL
Internal battery
External battery
Circuit
breaker
BLU
BLU
BRN
BRN
VIEW FROM REAR
Power
switch
BLU BRN BLK
BLU BRN RED
BRN
BLU
Line
filter
GRN/YEL
7-00119

Figure 2-24. Wiring diagram (2 of 2)

2.3.1 Power assembly

As illustrated in Figure 2-25, the power assembly includes power input components, the BBU PCB, and a recirculating fan. The harnesses shown in Figure 2-26 interconnect the parts of the power assembly. The ventilator head/power supply harness (Figure 2-27) connects the power assembly to the rest of the ventilator.


Power supply fan
BBU PCB/ ventilator head harness
Baffle
BBU PCB
Power supply
Side view
7-00125

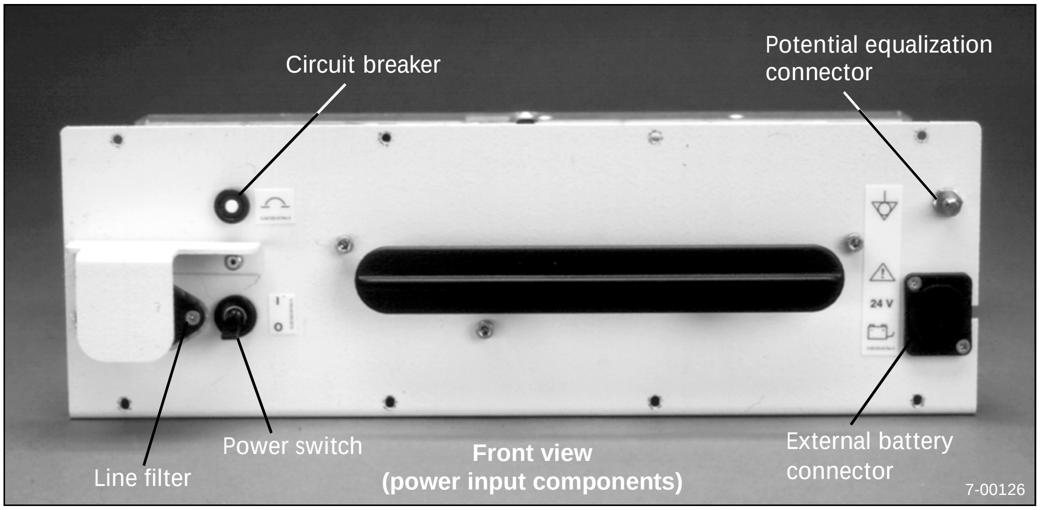
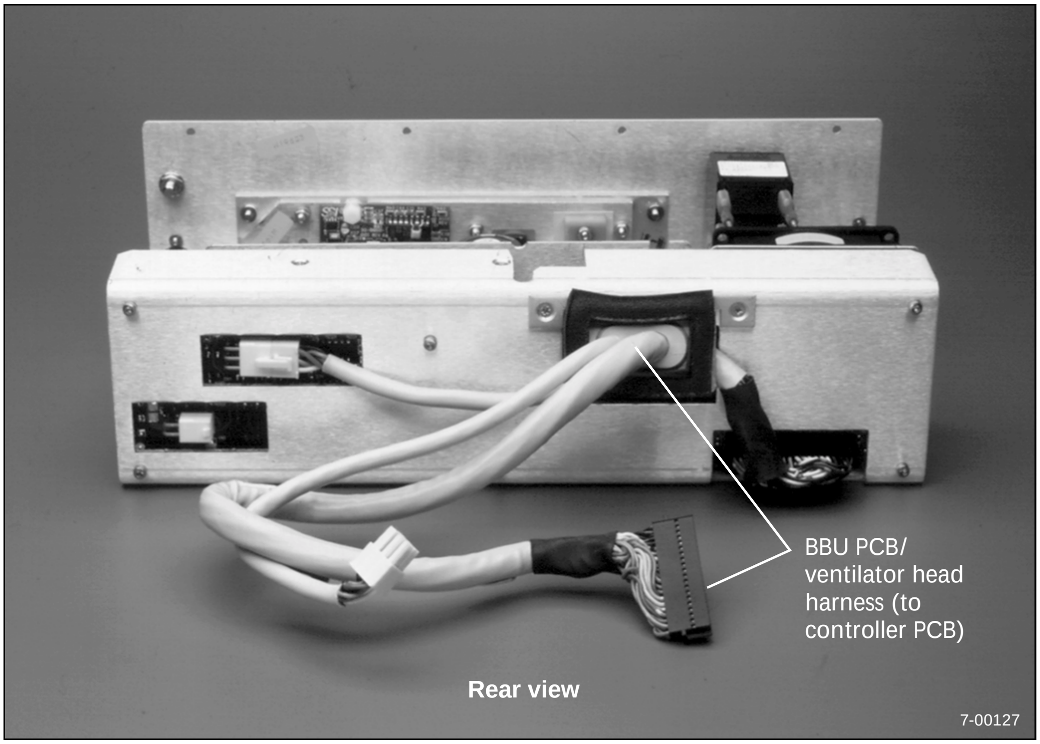

Circuit breaker
Potential equalization connector
24 V
Power switch
Line filter
Front view (power input components)
External battery connector
7-00126

Figure 2-25. Power assembly (1 of 2)


BBU PCB/
ventilator head
harness (to
controller PCB)
Rear view
7-00127

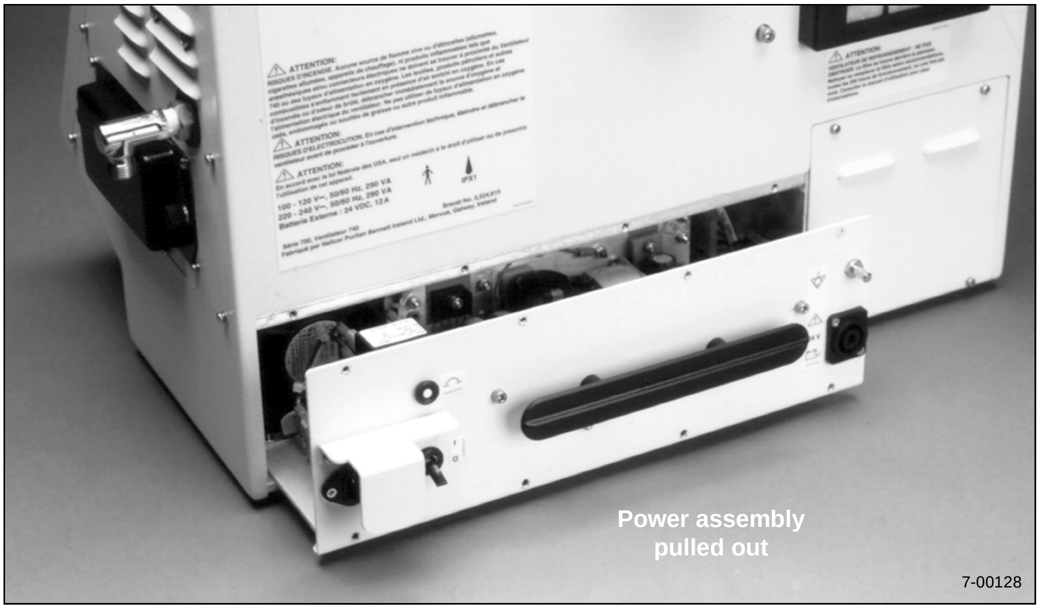

Power assembly
pulled out
7-00128

Figure 2-25. Power assembly (2 of 2)

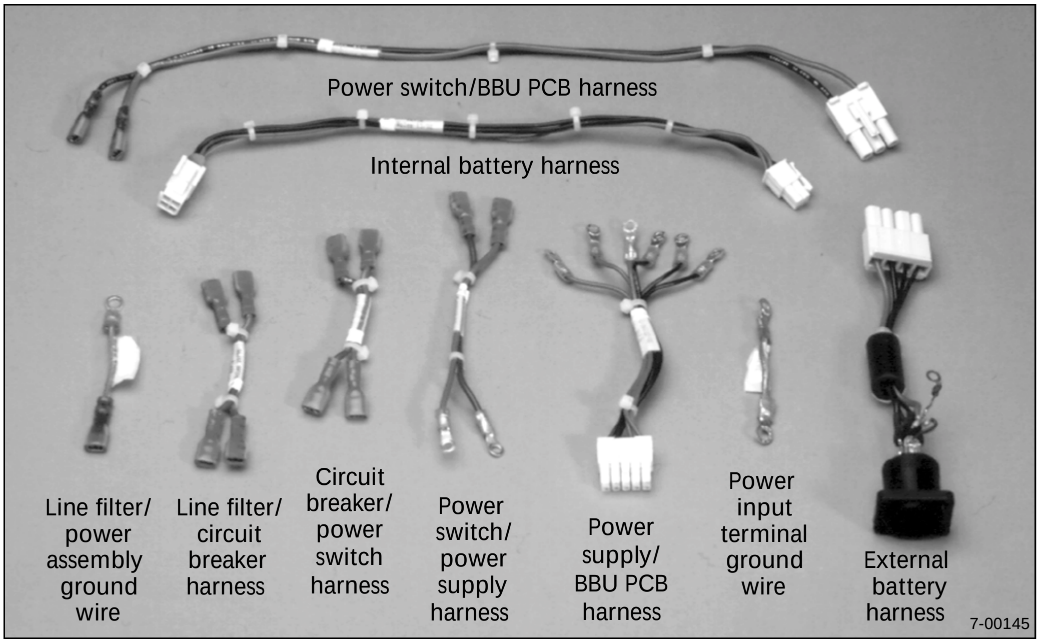

Power switch/BBU PCB harness
Internal battery harness
Line filter/ power assembly ground wire
Line filter/ circuit breaker harness
Circuit breaker/ power switch harness
Power switch/ power supply harness
Power supply/ BBU PCB harness
Power input terminal ground wire
External battery harness
7-00145

Figure 2-26. Power assembly harnesses

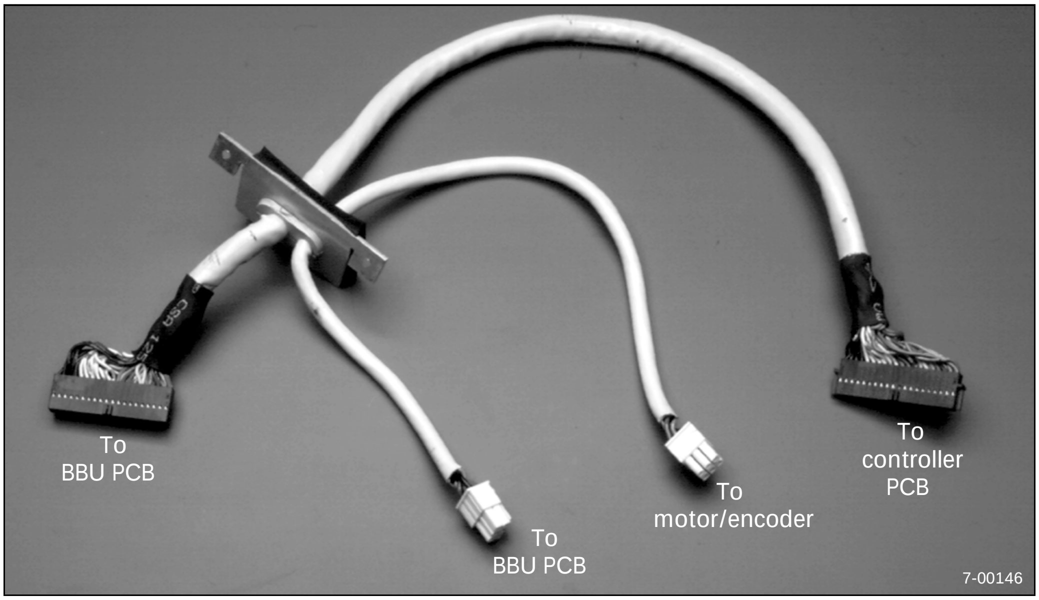

To BBU PCB
To BBU PCB
To motor/encoder
To controller PCB
7-00146

Figure 2-27. Power supply/ventilator head harness

2.3.1.1 Power input section

Illustrated in Figure 2-28, the power input section includes the power cord, line filter, circuit breaker, and power switch.

2.3.1.1.1 Power cord. The ventilator includes a detachable 3-m (10-ft) power cord. The cord has an IEC-standard right-angle, three-prong connector. The plug end varies, corresponding to different countries' requirements.

2.3.1.1.2 Line filter. The line filter includes an IEC-320 plug. The line filter reduces line noise to and from the ventilator.

2.3.1.1.3 Circuit breaker. The two-pole circuit breaker opens when the line current draw exceeds 4 A.

2.3.1.1.4 Power switch. The power switch, a single-throw, triple-pole toggle type, controls power to the ventilator. It is rated for 5 A, 250 V ac. The switch breaks both sides of the line. The third pole is used to disconnect the battery ground for purposes of storage or service. All power, including battery power, is removed when this switch is off. (Battery charging takes place when the power switch is on either in the standby mode or during ventilation when ac is present.)

2.3.1.1.5 Potential equalization connector. This connector provides a means of connection between the equipment and the potential equalization busbar of the electrical installation.

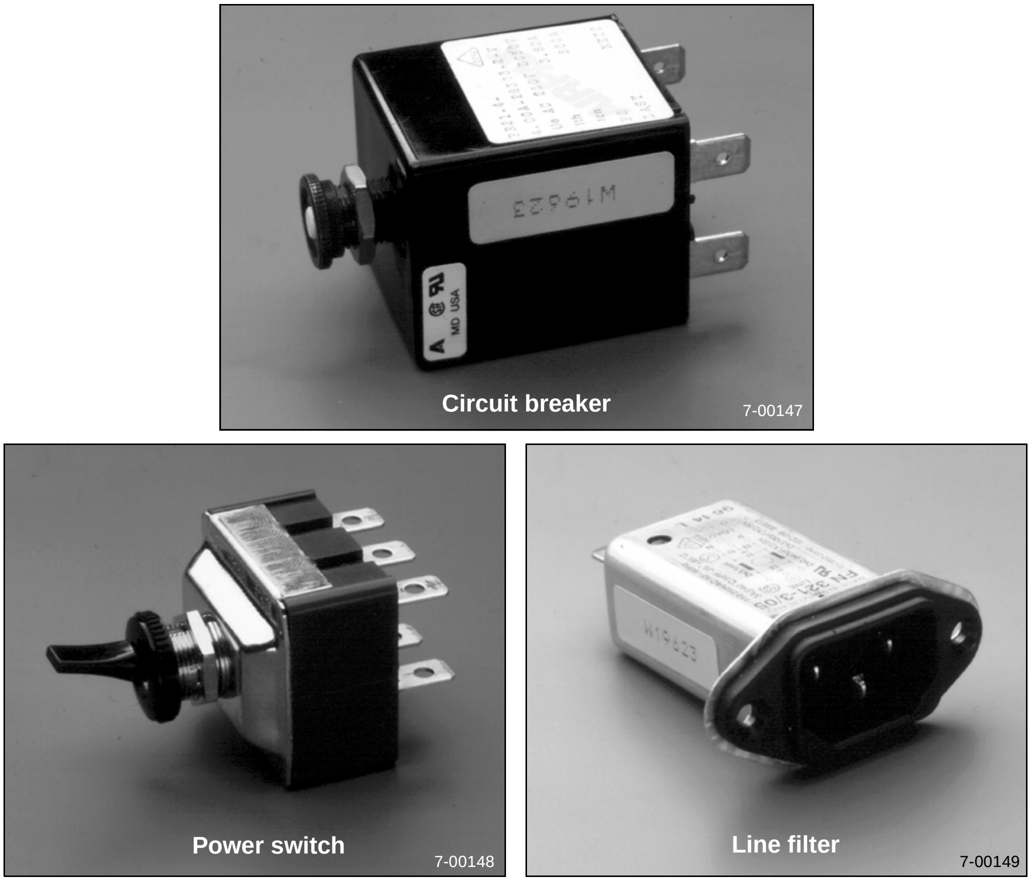


Figure 2-28. Power input components

2.3.1.2 Power supply

See Figure 2-29. The power supply outputs a constant regulated +24 V dc. It accepts input voltages in the ranges 85 to 134 V (110 V units) or 171 to 269 V (230 V units) at 45 to 65 Hz.

The power supply has a single, +24 V output, which is fused on the BBU PCB. It provides power for ventilation and battery charging. Voltages required by the PCBs are generated locally from the distributed +24 V.

The power supply is protected against overvoltage, overtemperature, overload, and load short circuit conditions.

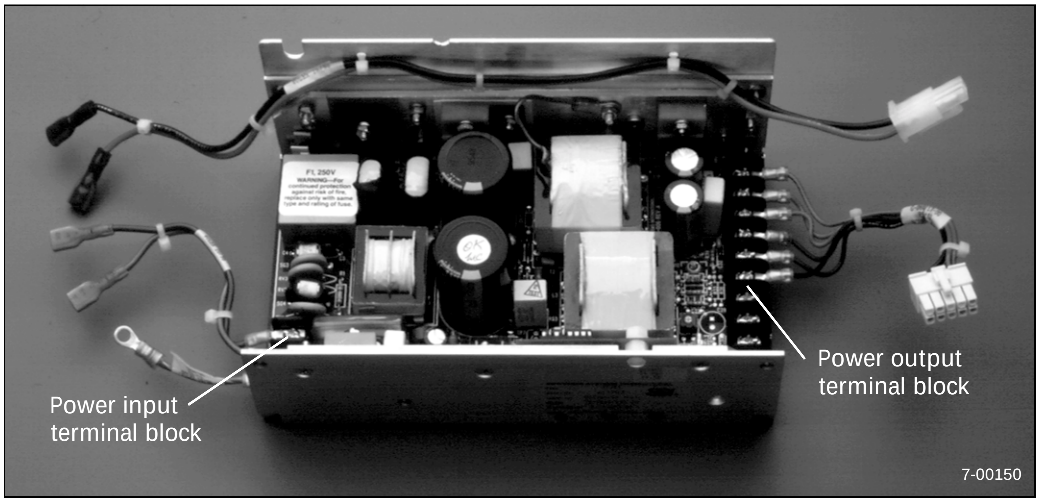


Figure 2-29. Power supply with harnesses

2.3.1.3 Battery backup (BBU) PCB

Figure 2-30 and Figure 2-31 illustrate the battery backup (BBU) PCB, which contains the circuitry needed to switch between available power sources, power the motor, and charge the internal and external batteries. It also monitors various supply voltages as well as the power assembly temperature.

- The **battery backup circuit** determines whether the ac source/power supply can provide a reliable +24 V output for ventilator operations. If the circuit determines that it cannot, then the circuit switches to external or internal battery as the power source. (For a complete description of the power source switchover operation, see Section 2.7.) This circuit operates independently of both microprocessors, although the UI microprocessor does test the batteries, monitor the battery backup circuit, and switch off battery power when the powering battery output falls below 21 V.
- To determine which power source to use, the battery backup circuit monitors the three +24 V outputs from the power supply, external battery, and internal battery. Normal ventilation can proceed if one of these outputs is at least +21 V. The ventilator's first choice is to operate from the power supply output (powered off the mains), then the external battery, and then the internal battery. Before operating from the power supply, however, the circuit verifies that the power

supply output is stable and remains stable for 3 seconds. This means that for the first 3 seconds after the ventilator power is turned on, the ventilator is powered by the external (if available and charged) or internal battery. After 3 seconds, provided the power supply output is determined to be acceptable, the ventilator switches from operating from the battery to operating from the power supply.

- If none of the three power sources is acceptable, the ventilator attempts an orderly shutdown of the ventilator circuits.
- The **motor drive circuit** includes power MOS FETs in a bridge configuration to drive the brushless dc motor. It limits current to the motor to prevent excessive patient wye pressure. It works in conjunction with the motor controller circuit (on the controller PCB) and the motor/encoder to provide the velocity and torque profiles capable of delivering the full range of ventilator flows and pressures. See Section 2.5 for a discussion of the motor control and drive operation.
- The **battery charger circuit** charges the internal and external batteries while the ventilator is operating on ac power with the power switch on. This circuit monitors the charging current of both batteries and the discharging current of the battery currently in use. If the battery voltage drops below +25 V, the charger boosts the charging voltage to +29.4 V (± 20%). The battery pack's float voltage is +27.4 V (± 20%); this float voltage charging level decreases with increasing battery compartment temperature.
- Inputs from the **voltage and temperature monitor** allow the controller PCB to monitor the two battery voltages, the power supply voltage, and local dc voltages, as well as the power assembly temperature. The ventilator's UI shows the charge level of the internal battery.
- Replaceable **fuses** on the PCB protect these lines:
  - Input from power supply (F6) (15 A, standard, T-type)
  - Motor drive (F1) (10 A, fast-blow, F-type)

  In addition, the PCB has several nonreplaceable thermal fuses that stop conducting when current exceeds their rating, but which begin conducting again after they cool and current returns to acceptable levels.
- **LEDs** on the PCB permit monitoring of these lines; they can be viewed when the power assembly is partially disassembled:
  - Power source inputs to PCB - Power supply (MAIN ON), external battery (EXT ON), and internal battery (INT ON)
  - Main +24 V power from selected source (+24V MAIN)

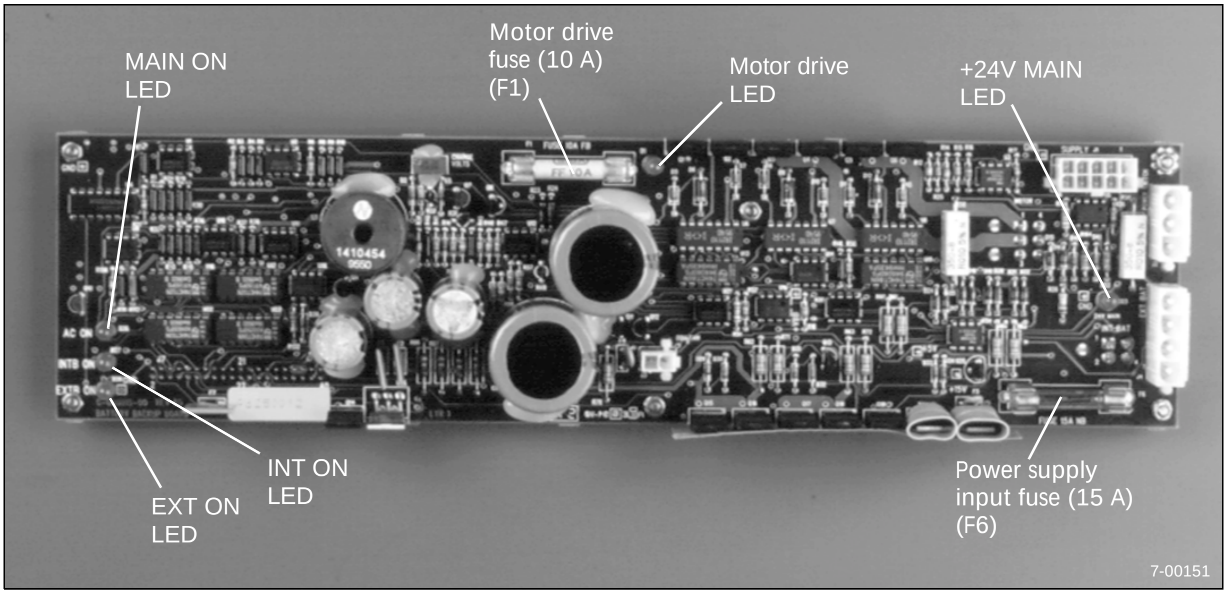

MAIN ON LED
Motor drive fuse (10 A) (F1)
Motor drive LED
+24V MAIN LED
INT ON LED
EXT ON LED
Power supply input fuse (15 A) (F6)
7-00151

Figure 2-30. BBU PCB

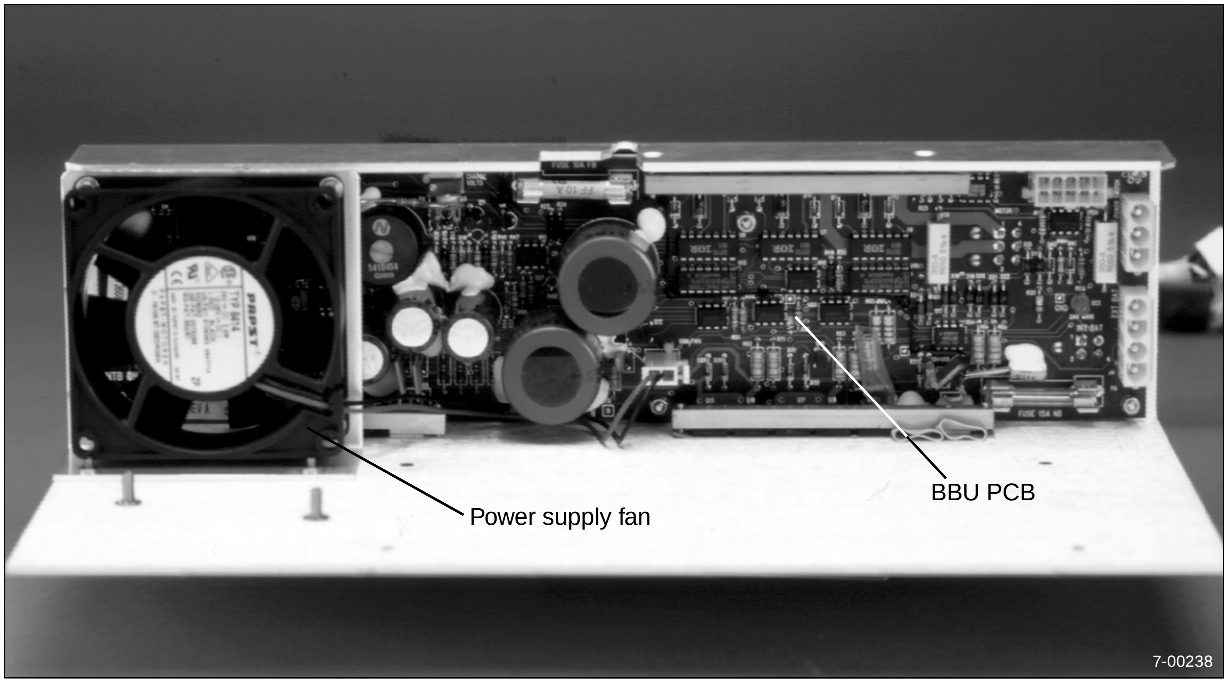

BBU PCB
Power supply fan
7-00238

Figure 2-31. BBU PCB and fan installed in power assembly

2.3.1.4 Power supply fan (Figure 2-31 and Figure 2-32)

An internal +24 V fan recirculates the air within the power assembly.

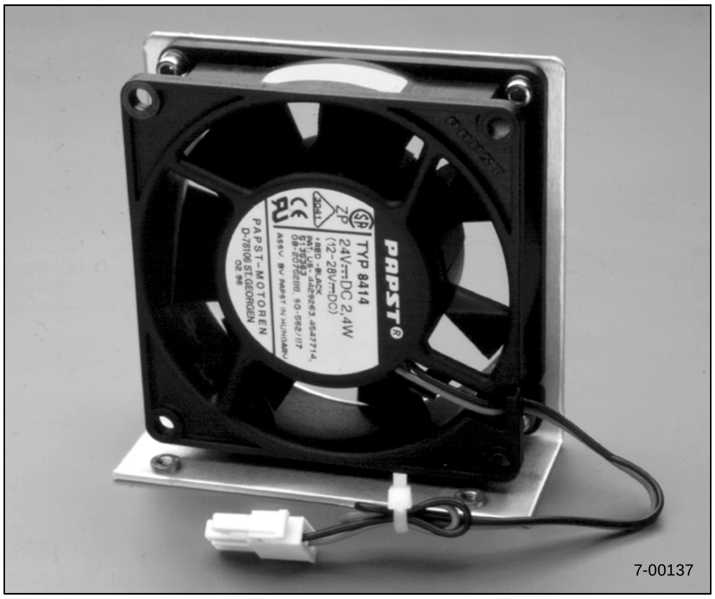


Figure 2-32. Power supply fan

2.3.2 Internal battery (Figure 2-33 and Figure 2-34)

The internal battery, a lead-acid type, provides a backup for the ac power. It provides +21 to +26 V to supply the ventilator's electrical components. The ventilator operates from the internal battery if the power supply output is unacceptable and the external battery is not installed or not adequately charged (see Section 2.7). The battery charges automatically while the ventilator is connected to ac power and the power switch is on (including when in the standby mode). A new, fully charged internal battery can operate the ventilator for approximately 2.5 hours under nominal conditions (tidal volume 0.6 L, respiratory rate 15 breaths/min, PEEP/CPAP 5 cmH_2O, peak flow 60 L/min, plateau 0 s; average peak pressure 30 cmH_2O, average mean pressure 8 cmH_2O).

The battery is housed in a nonmetallic container that is vented to ambient air and sealed from the interior of the ventilator.

Through the ventilator's UI, you can view the charge level of the internal battery. A menu function lets you see the approximate hours of internal battery life remaining. The internal battery replacement interval is approximately every two years.

Warning

Do not use the ventilator unless it has at least one minimally charged battery. The ventilator may not be protected from power dropout in the absence of a battery.

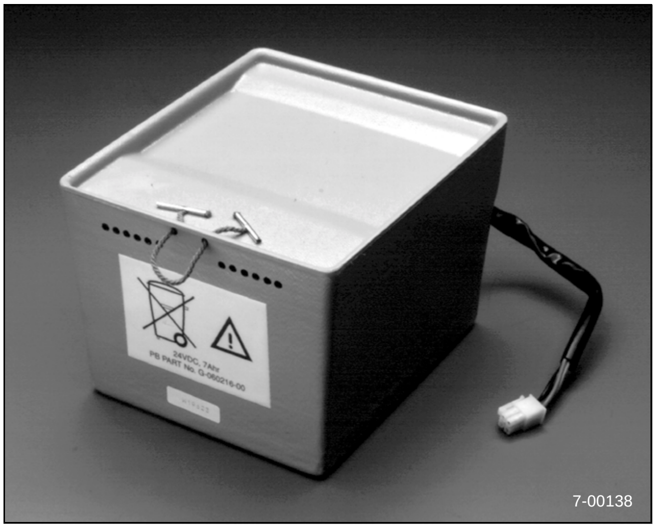


Figure 2-33. Internal battery

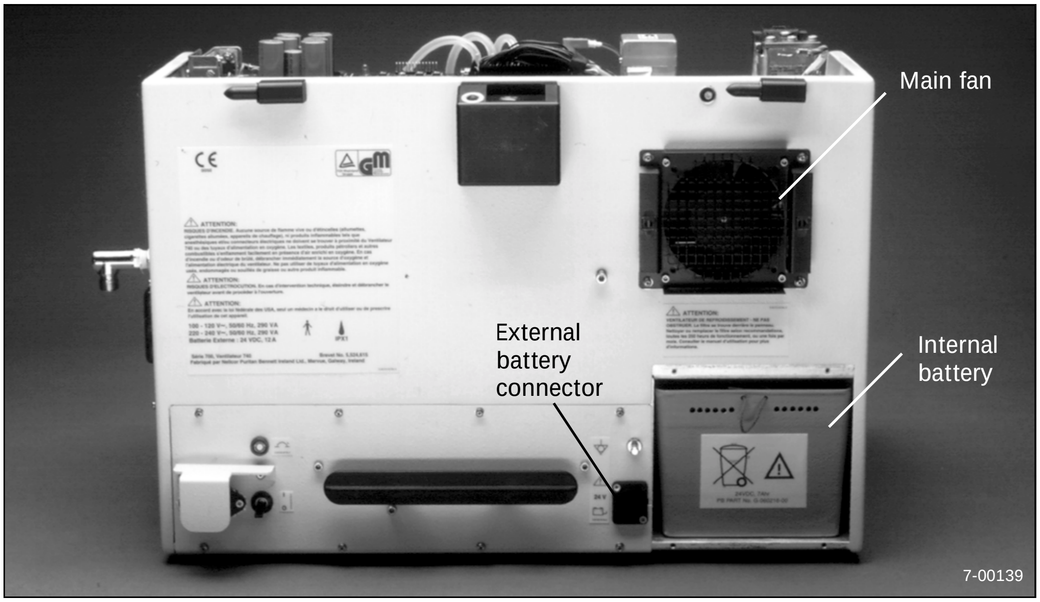


Figure 2-34. Internal battery and main fan installed in ventilator

2.3.3 External battery (Figure 2-35)

The optional external battery, a lead-acid type, provides backup for the ac power. It supplies +21 to +26 V to supply the ventilator's electrical requirements. The ventilator operates from the external battery if the power supply output is unacceptable, provided the external battery is installed and adequately charged (see Section 2.7). A new, fully charged external battery can operate the ventilator for approximately 7 hours under nominal conditions (tidal volume 0.6 L, respiratory rate 15 breaths/min, PEEP/CPAP 5 cmH_2O, peak flow 60 L/min, plateau 0 s; average peak pressure 30 cmH_2O, average mean pressure 8 cmH_2O).

The external battery is connected to the ventilator through the external battery connector (Figure 2-34). This connector has a jumper that allows the ventilator to recognize that the external battery is installed. The external battery is enclosed in a separate case designed to mount under the ventilator on a shelf.

The external battery replacement interval is approximately every two years. A menu function lets you see the approximate hours of external battery life remaining. The battery contains a replaceable fuse.

Warning

Do not use the ventilator unless it has at least one minimally charged battery. The ventilator may not be protected from power dropout in the absence of a battery.

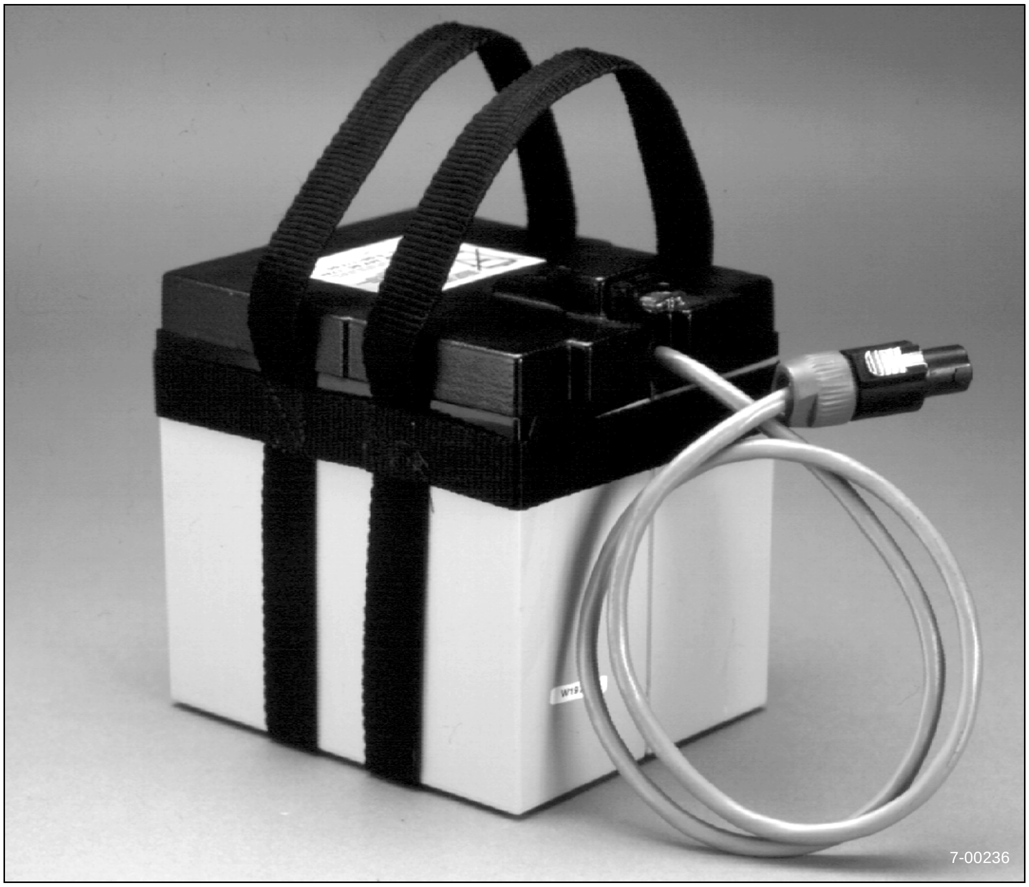


Figure 2-35. External battery

2.3.4 Pressure solenoid PCB (Figure 2-36 and Figure 2-37)

The pressure solenoid PCB contains these circuits:

- The **pressure transducer/interface circuit** includes pressure transducers and supporting circuitry used to obtain pressure measurements throughout the ventilator. These onboard transducers monitor these pressures:
  - Inspiration/atmospheric
  - Exhalation
  - Cylinder

  - Exhalation flow sensor differential (two inputs) (This sensor uses as inputs pressures from either side of a fine mesh screen in the exhalation system. The pressure differential is directly proportional to the exhaled flow.)

  In addition, the circuit interfaces an oxygen regulator pressure transducer, which is located in the oxygen solenoid assembly, and an oxygen sensor, which is located in the inspiration manifold.

- The **solenoid drive circuitry** switches and drives the solenoids within the ventilator.
- The **audible alarm drive circuit** sounds the ventilator’s main speaker alarm. A separate secondary piezo alarm driver circuit provides redundancy if the main alarm fails.
- 2 Kbits of **serial EEPROM** store pressure transducer offsets and gains.
- The **PEEP drive circuit** sends a pulse-width modulated signal to control the output of the PEEP pump.
- The **thermistor/interface circuit** includes an onboard thermistor that senses internal ventilator compartment temperature. It provides supporting circuitry for it and these additional offboard thermistors: exhalation (2 inputs), inspiration, and air flow (2 inputs).
- The **safety valve circuit** de-energizes the safety valve solenoid if the cylinder or exhalation (patient) pressure exceeds 115 cmH_2O, which opens the safety valve to atmosphere. This circuit provides redundancy for the software. (The safety valve is opened under software control at 92 cmH_2O cylinder pressure and in other circumstances.)
- The **fan circuit** detects an open circuit to the main fan or a stalled fan condition. The fan must always be on when the unit is ventilating.
- The **heater circuit** controls the exhalation heaters. The heaters’ temperature is maintained at approximately 50 ^{o}C. A thermistor that is in contact with one of the heaters provides feedback used to control the heaters’ temperature. The second thermistor serves as a backup monitor.
- The **tachometer circuit** measures the piston velocity.
- **LEDs** on the PCB permit monitoring of these lines:
  - Local voltages (+5V ON, +15V ON, and -15V ON) (constant LEDs)
  - Exhalation heater (MANIFOLD HEAT ON) (flashing LED with varying duty cycle)
  - Flow sensor pressure transducer heater (for temperature compensation) (TRANS HEAT ON) (flashing LED with varying duty cycle)
- The **voltage monitor test connector (J2) can be used to check these local voltages: +1.2 V, +5 V, UI-5V, +15 V, -15 V, and +24 V.**

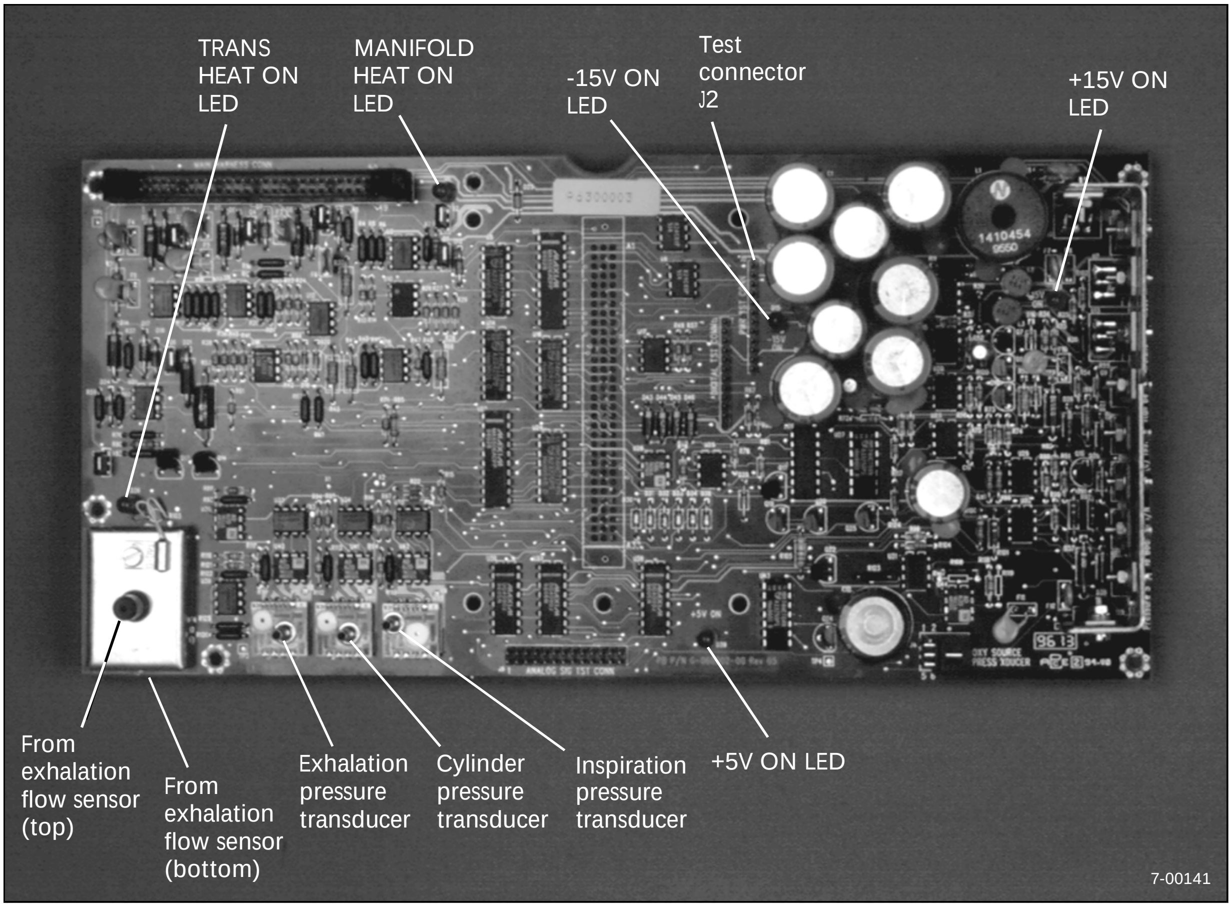

TRANS HEAT ON LED
MANIFOLD HEAT ON LED
-15V ON LED
Test connector J2
+15V ON LED
From exhalation flow sensor (top)
From exhalation flow sensor (bottom)
Exhalation pressure transducer
Cylinder pressure transducer
Inspiration pressure transducer
+5V ON LED
7-00141

Figure 2-36. Pressure solenoid PCB

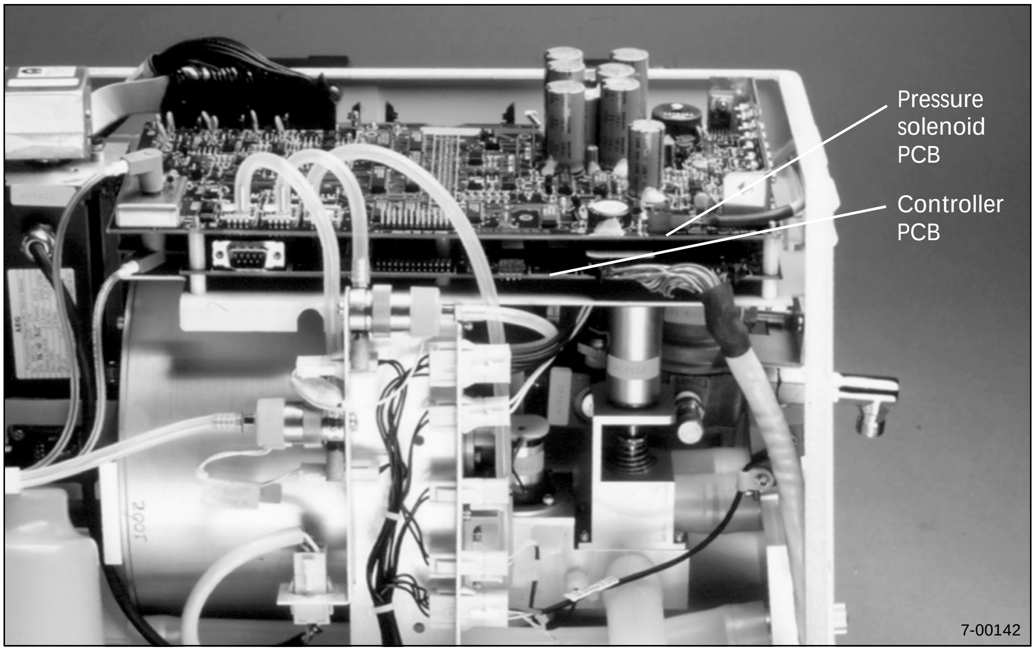

Pressure solenoid PCB
Controller PCB
7-00142

Figure 2-37. Pressure solenoid and controller PCBs installed

2.3.5 Controller PCB (Figure 2-37 and Figure 2-38)

The controller PCB has two sections: the breath delivery (BD) and the user interface (UI) sections. These sections are physically separate, each residing on one half of the PCB. Each section contains its own microprocessor and external memory. The BD section controls the electronic and pneumatic components that ventilate the patient. The UI section reads and interprets information from the operator via the keypad, knob and displays; it also monitors the BD. Both sections communicate continuously with each other.

The BD section includes these circuits, which perform the indicated functions:

- The **CPU section** includes a Motorola 68HC16 **microcontroller**, which operates at 16 MHz. (The microcontroller chip contains a microprocessor, clock, internal watchdog, memory, an I/O interface, and A/D converter.) Two EPROMs (Figure 2-39) totaling up to 512 KB contain the software for the BD section. These plug into the PCB and must be retained with the ventilator when a replacement controller PCB is installed. 64 KB of RAM is used for ongoing calculations and data storage.
- The **motor controller circuit** is a special-purpose chipset that monitors the position of the motor shaft and controls the motor drive circuitry on the BBU PCB.
- **I/O registers** allow monitoring and control of solenoids, optoswitches, and audible alarms.
- The **ventilator inoperative circuit** invokes the safety valve open (SVO) condition and generates audible/visual alarms in the event of a catastrophic failure.
- The **external watchdog circuit** monitors for safe CPU operation.
- The **optoswitch circuit** provides interfacing for the optoswitches.

The UI section includes these circuits, which perform the indicated functions:

- The **CPU section** includes a Motorola 68HC16 microcontroller, which operates at 16 MHz. (The microcontroller chip contains a microprocessor, clock, internal watchdog, memory, an I/O interface, and A/D converter.) Two EPROMs (Figure 2-39) totaling up to 512 KB contain the language-specific software for the UI section. These plug into the PCB and must be retained with the ventilator when a replacement controller PCB is installed. 64 KB of RAM is used for ongoing calculations and data storage.
- 2 KB of **NVRAM** (nonvolatile RAM) stores critical calculated information including the serial number, hours of operation, offsets and gains for the transducers (which are based on the initial data in the EEPROM on the pressure solenoid PCB, and are updated at every calibration; use the *Update prsol nvram* function in the service menu when replacing the pressure solenoid PCB), and other service data, and ventilator settings (see Table 2-2). The NVRAM device plugs into a socket on the PCB. This device must be retained with the ventilator when a replacement controller PCB is installed.
- **I/O registers** allow control of LEDs in the UI. They also control the battery charger (on the BBU PCB). They allow monitoring of status throughout the ventilator.
- The **real-time clock** tracks the day and date.
- The **keyboard controller** provides an interface for the keyboard.

- The RS-232 **serial communications port** permits connection to an external computer for uploading/downloading service information and for future communications options. Not functional if the Communications option is installed (port A on the Communications panel is used instead).
- The **knob decoder**, used in conjunction with the knob encoder, decodes the direction and amount of knob movement.

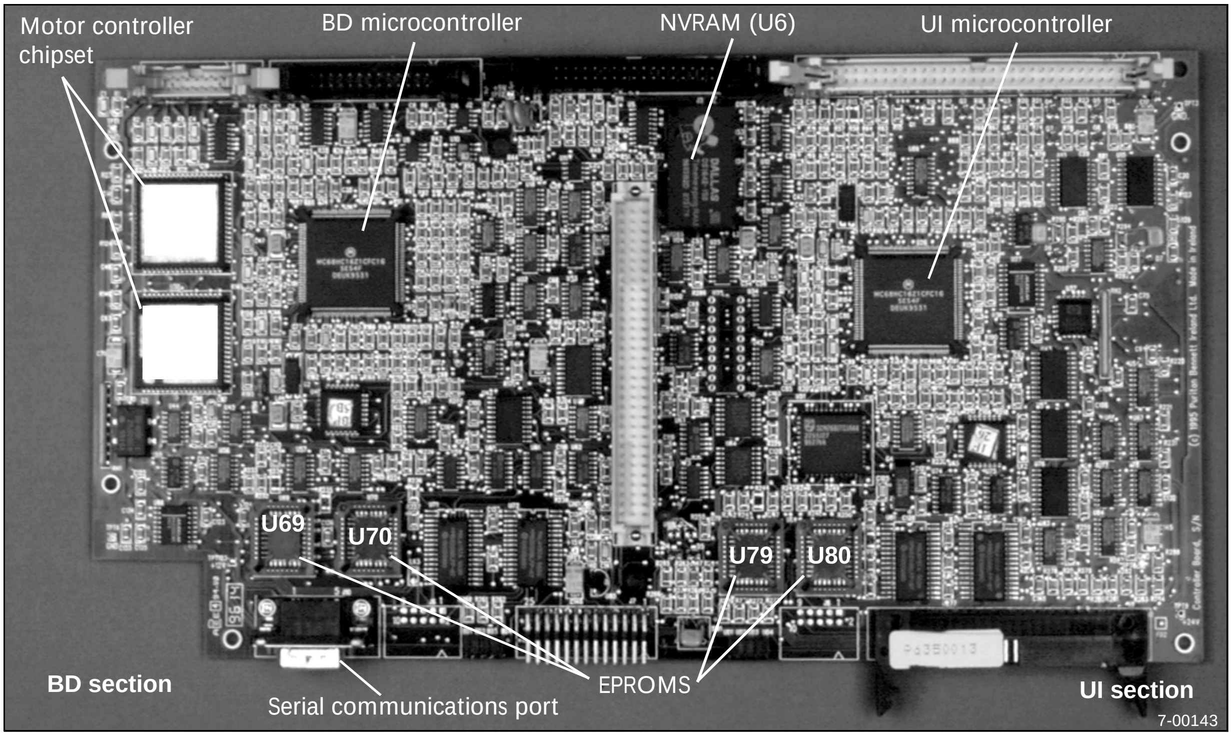

Motor controller chipset
BD microcontroller
NVRAM (U6)
UI microcontroller
U69
U70
U79
U80
BD section
Serial communications port
EPROMS
UI section
7-00143

Figure 2-38. Controller PCB

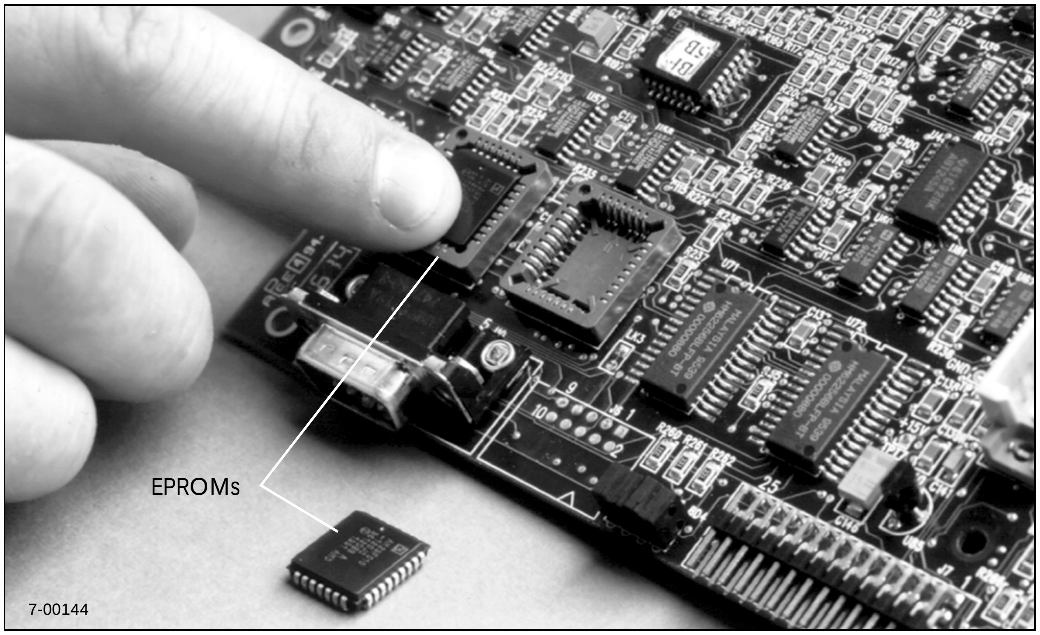

EPROMs
7-00144

Figure 2-39. EPROM

Table 2-2: NVRAM contents

Type of data	Parameter	Notes
Service data	Ventilator serial number	
Service data	Total number of breaths	Updated every 100 breaths.
Service data	Hours of operation (excluding standby mode, SST, EST, calibration, and service menu operation)	
Service data	Number of times high-flow and low-flow oxygen solenoids have been cycled	
Service data	Estimated oxygen sensor life remaining, in hours	Based on current O_2 % setting. The greater the percentage oxygen in use, the lower the life.
Service data	Hours internal battery has powered ventilator	
Service data	Hours remaining until preventive maintenance is due	
Service data	Number of times autozero solenoids have been turned on	Total number of on times for the exhalation pressure transducer autozero solenoid and cylinder pressure transducer autozero solenoid.
Service data	Current time, in number of seconds since 1/1/96.	Updated every hour.
Calibration and other constants	Exhalation flow sensor resistance constant	Must be input when new exhalation flow sensor installed
Calibration and other constants	Cylinder leak constant lookup table	Must be input when new piston/ cylinder installed. Cross-checked during EST.
Calibration and other constants	Number of motor quadcounts between home and end positions	Must be input when new piston/ cylinder installed
Calibration and other constants	Oxygen mixing constants, including flows from orifices and regulator pressures	Must be input when new oxygen regulator assembly installed
Calibration and other constants	PEEP pump calibration lookup table	Source: PEEP pump calibration. Lookup table updated during EST and calibration verified.
Calibration and other constants	Current of PEEP pump at 0% duty cycle.	Value in counts. Currently unused.
Calibration and other constants	Oxygen regulator pressure transducer calibration data	Source: oxygen regulator pressure transducer calibration. Checked during EST.

Table 2-2: NVRAM contents (continued)

Type of data	Parameter	Notes
Calibration and other constants	Oxygen sensor (FIO_2) calibration data	Calibration verified during FIO_2 calibration check
Calibration and other constants	Pressure solenoid calibration constraints	Updated when new pressure solenoid board is installed and during calibration. Operator accesses via menu.
Ventilator configuration	Ventilator breathing circuit resistance and compliance	Source: SST/EST (circuit resistance field currently unused)
Ventilator configuration	Endotracheal tube size, in mm	Source: SST/EST
Ventilator configuration	Ventilator breathing circuit type	Source: SST/EST
Ventilator configuration	Model	
Ventilator configuration	Humidification device type	Source: SST/EST
Ventilator configuration	Circuit characteristic change	Indicates whether there has been a change to the circuit type, humidification device, or ET tube size, used to determine whether circuit compliance test must be run before skipping to the end of SST or EST.
Ventilator options	Nebulizer settings	Most recently selected nebulization phase and length of nebulization time
Ventilator options	Serial port configuration	Most recently selected settings for serial ports A and B
Operator settings	Breath settings	
Operator settings	Alarm settings	
Operator settings	Apnea settings	
Operator settings	Main alarm volume	Range: 1 - 5
Operator settings	Pressure units	Range: cmH_2O or hPa
Operator settings	Date format selection	Range: Month or day first (US or European)
Operator settings	Time format selection	Range: 12- or 24-hour clock
Extended data	Number of hours at various mean pressure ranges	Recorded for these ranges: 0 to 9 cmH_2O, 10 to 19 cmH_2O, 20 to 29 cmH_2O, 30 to 39 cmH_2O, 40 to 49 cmH_2O, and above 50 cmH_2O.

Table 2-2: NVRAM contents (continued)

Type of data	Parameter	Notes
Extended data	Oxygen solenoid data, including rise time constant, on time constant, and offset volume for high-flow oxygen solenoid; time delay between opening solenoids and retracting piston; on time constant and offset volume for low-flow oxygen solenoid.	Currently unused
Extended data	Gains and offsets for various transducers stored in EEPROM on pressure solenoid PCB	
Error logs	Alert log	Technical alerts and other conditions detected during ongoing checks
Error logs	Test log	Conditions detected during calibration tests, POST, SST, and EST (may also contain some conditions recorded in the alert log).
SST data	Whether individual tests were run, whether a fault or incomplete was overridden (by pressing MANUAL INSP), the tests' pass/fail status, overall pass/fail status, time of most recent SST execution	
EST data	10 most recently detected EST or SST errors	

2.3.6 User interface (UI) (Figure 2-40)

The UI includes the UI display PCB, keyboard, and knob encoder.

The **UI display PCB** (Figure 2-41) includes three main sections: patient data, ventilator settings, and ventilator status. LCDs (liquid crystal displays) and LEDs (light-emitting diodes) on the PCB display data.

- A **4-line x 20-character LCD panel** (message window) (Figure 2-42) displays menus, ventilator settings, and ventilator status information.
- **LCDs** (windows) provide 7-segment representations of either settings or monitoring data (The *740* Ventilator has 12 LCDs, and the *760* Ventilator has 14 LCDs).
- There are three main categories of **LED**, as follows:
- **Bar graph LEDs** display airway pressure (*740* and *760* Ventilators) and exhaled volume (*760* Ventilator only).
- **Key confirmation LEDs** display whether a key is selected and the type of breath delivered.

- **Ventilator status LEDs** are high-power indicators, which display the functional status of the ventilator.

A membrane **keyboard assembly** (Figure 2-43) is attached to the UI PCB. Circuitry on the controller PCB senses pressed keys. A software debounce routine protects against unintended multiple keystrokes.

The multiposition **knob encoder** (Figure 2-44) permits setting selections or changes. It operates according to the same principles as the optical encoder used with the motor (see Section 2.2.2). A knob decoder on the controller PCB determines the direction and position of the shaft based on encoder outputs.

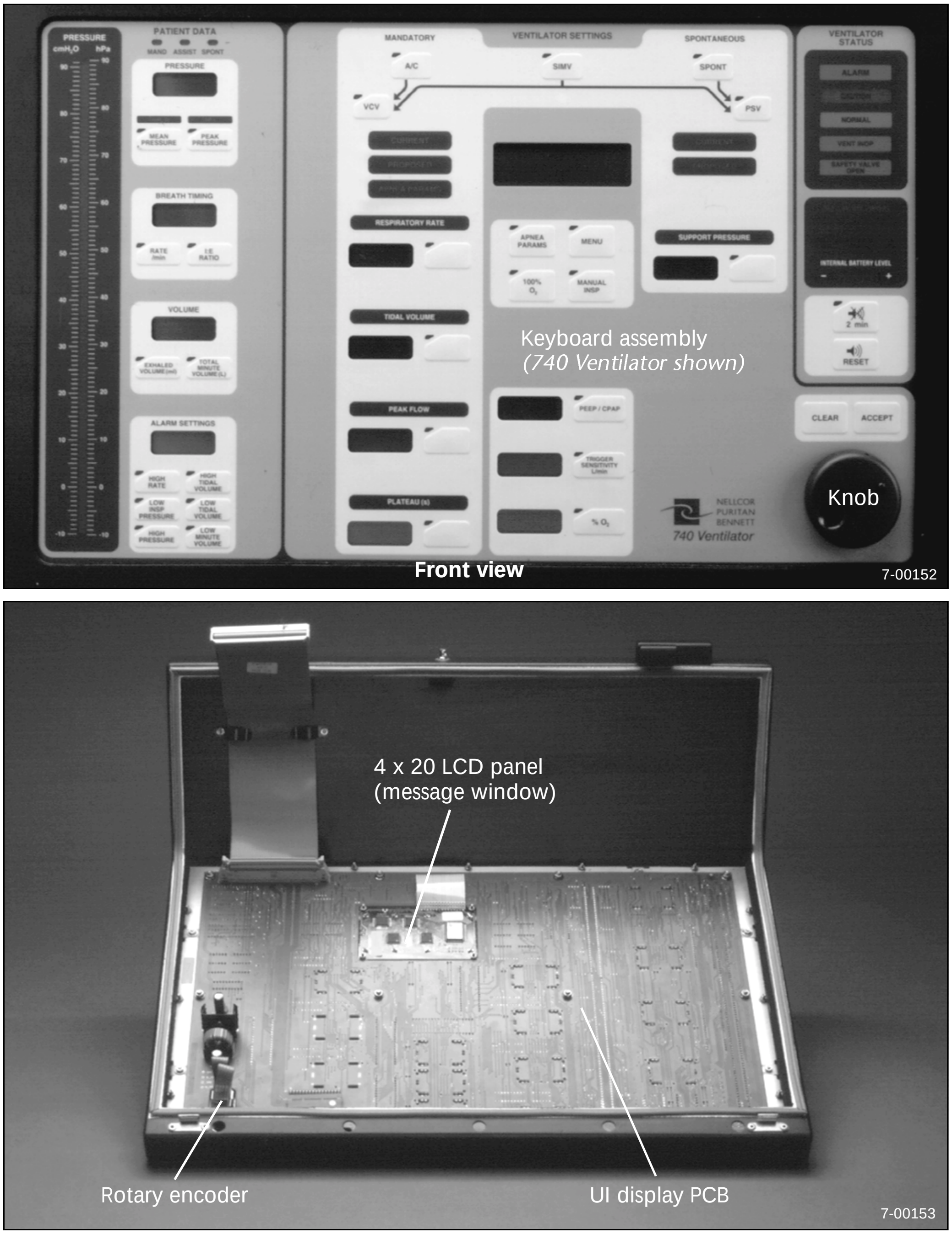

Keyboard assembly
(740 Ventilator shown)
Knob
Front view
7-00152
4 x 20 LCD panel
(message window)
Rotary encoder
UI display PCB
7-00153

Figure 2-40. User interface (UI)

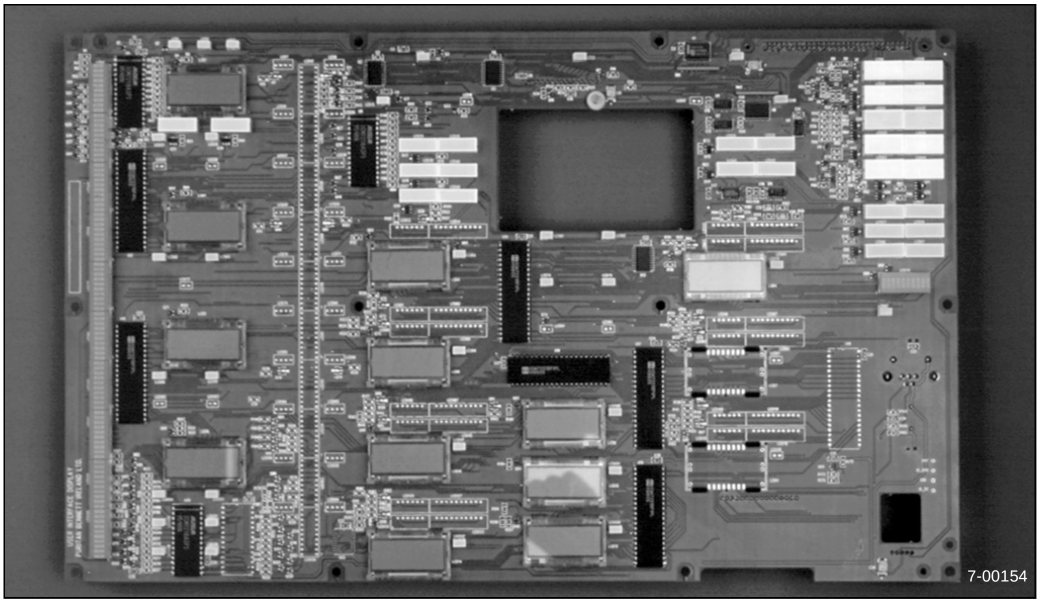


Figure 2-41. UI display PCB (740 shown)

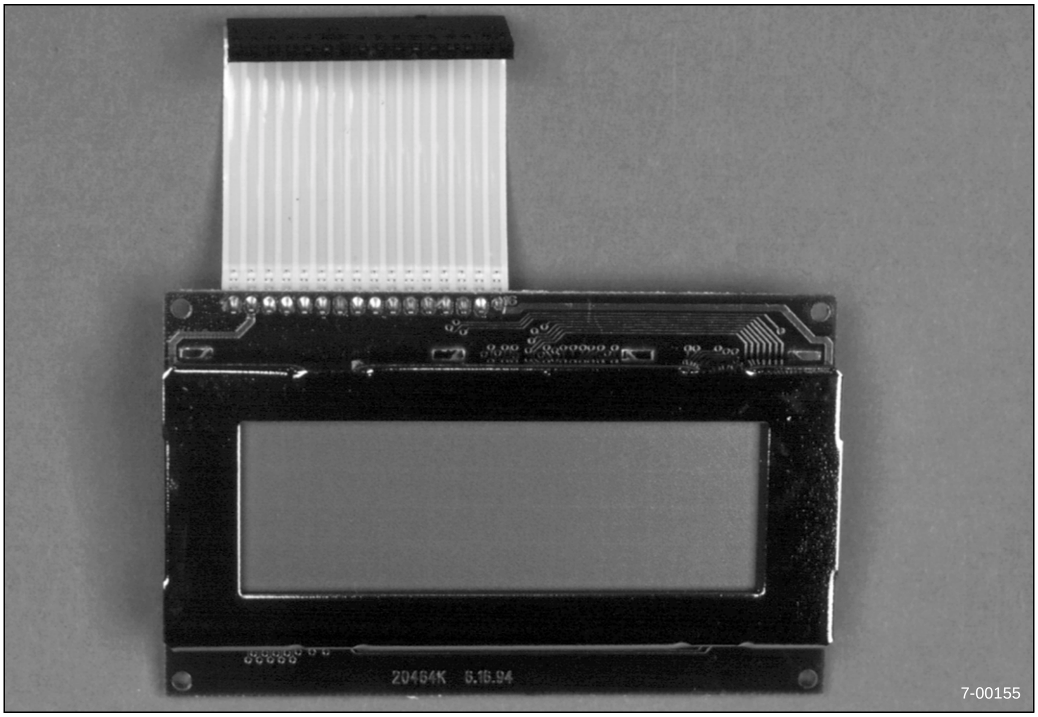

20464K 6.16.94
7-00155

Figure 2-42. 4-line x 20-character LCD panel (message window)

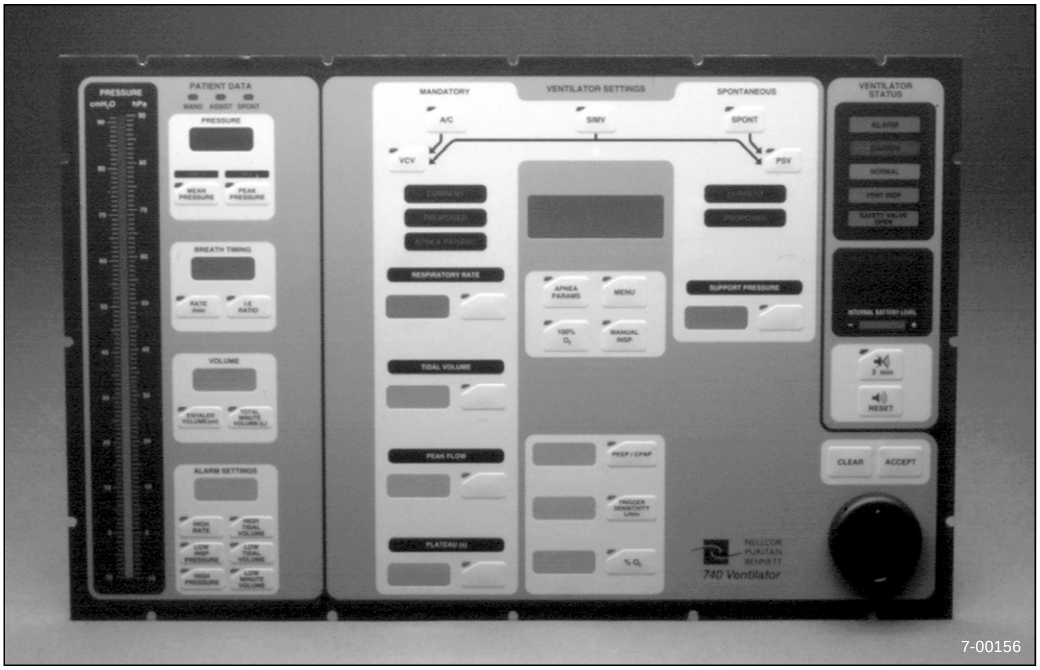

PRESSURE
PATIENT DATA
MANDATORY
VENTILATOR SETTINGS
SPONTANEOUS
VENTILATOR STATUS
A/C
SIMV
SPONT
VCV
PSV
CLEAR
ACCEPT
740 Ventilator
7-00156

Figure 2-43. Keyboard assembly (*740* shown)

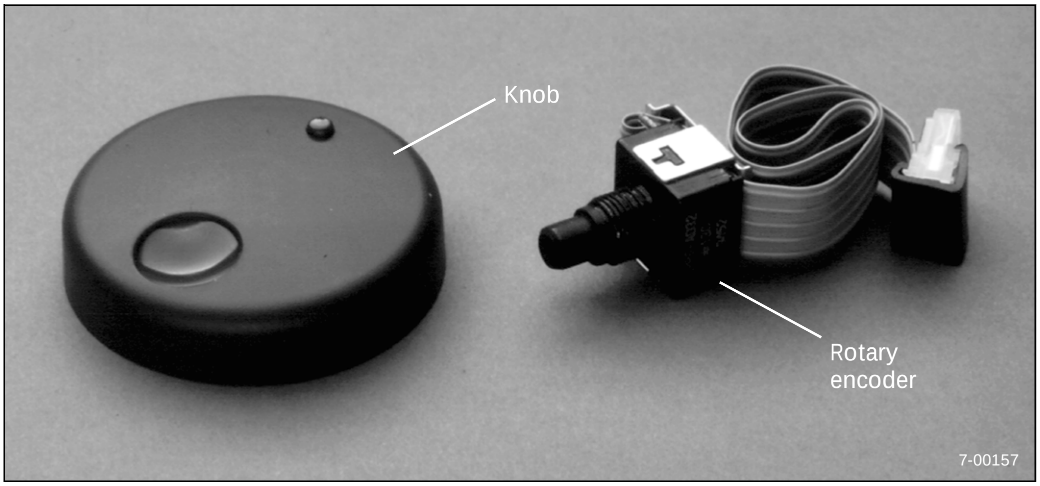

Knob
Rotary encoder
7-00157

Figure 2-44. Rotary encoder with knob

2.3.7 Miscellaneous electronic parts

2.3.7.1 Speaker (Figure 2-45 and Figure 2-47)

The speaker provides a multi-frequency alarm. The speaker volume, which has five settings, is software-controlled through the MENU key.

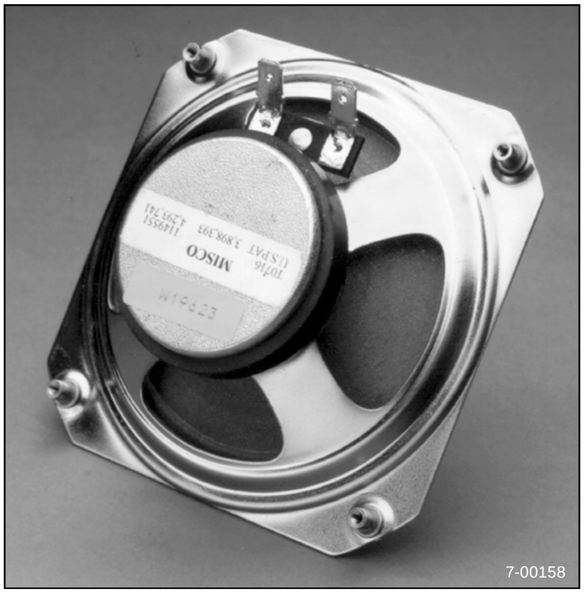


Figure 2-45. Speaker

2.3.7.2 Piezo alarm (Figure 2-46 and Figure 2-47)

The piezo alarm serves as a backup for the speaker. It can sound for two or more minutes. The alarm sounds under these conditions: following a total loss of power (in certain circumstances); when the ongoing tests detect a main alarm failure; and during part of POST, SST, and EST.

NOTE:

If the ventilator does not have a battery or the battery is inadequately charged, the piezo alarm will sound when the ventilator is powered off. The ventilator interprets this powering down as an unintentional total loss of power.

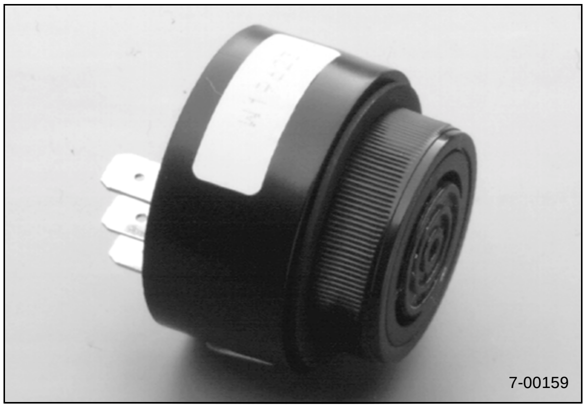


Figure 2-46. Piezo alarm

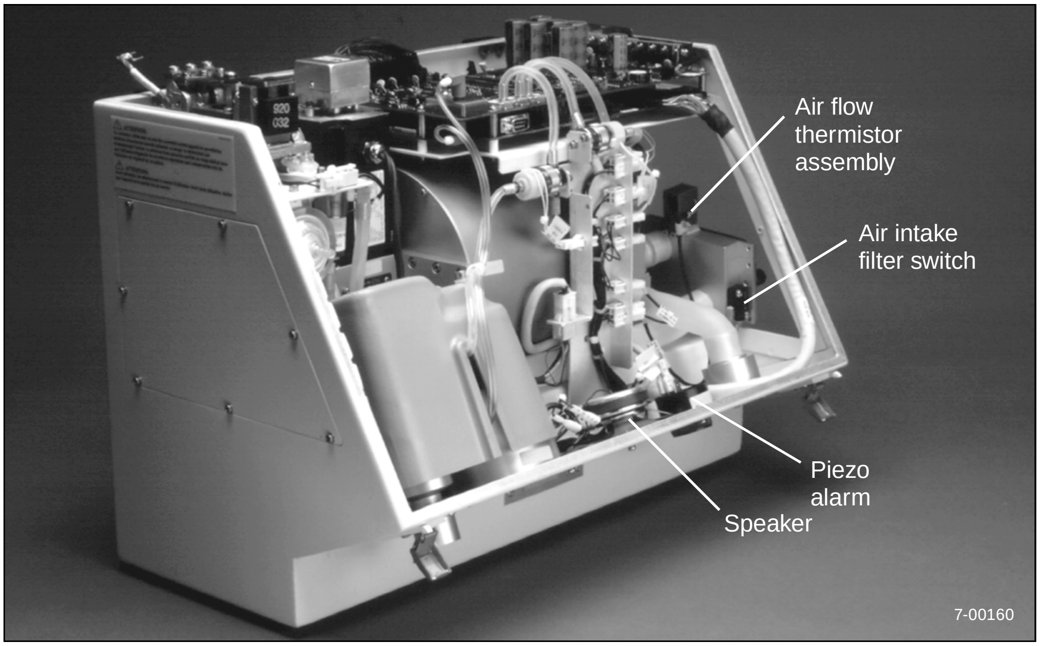

Air flow thermistor assembly
Air intake filter switch
Piezo alarm
Speaker
7-00160

Figure 2-47. Speaker, piezo alarm, air flow thermistor assembly, and air intake filter switch installed

2.3.7.3 Main fan (Figure 2-48 and Figure 2-34)

The main fan draws air into the ventilator to cool the interior and to dissipate oxygen in the event of an oxygen leak. It runs continuously during ventilation. The fan maintains the oxygen percentage inside the ventilator at less than 25%. To monitor this air flow, the ventilator incorporates an air flow thermistor assembly (see Section 2.3.7.4). A filter removes particles from the air drawn in.

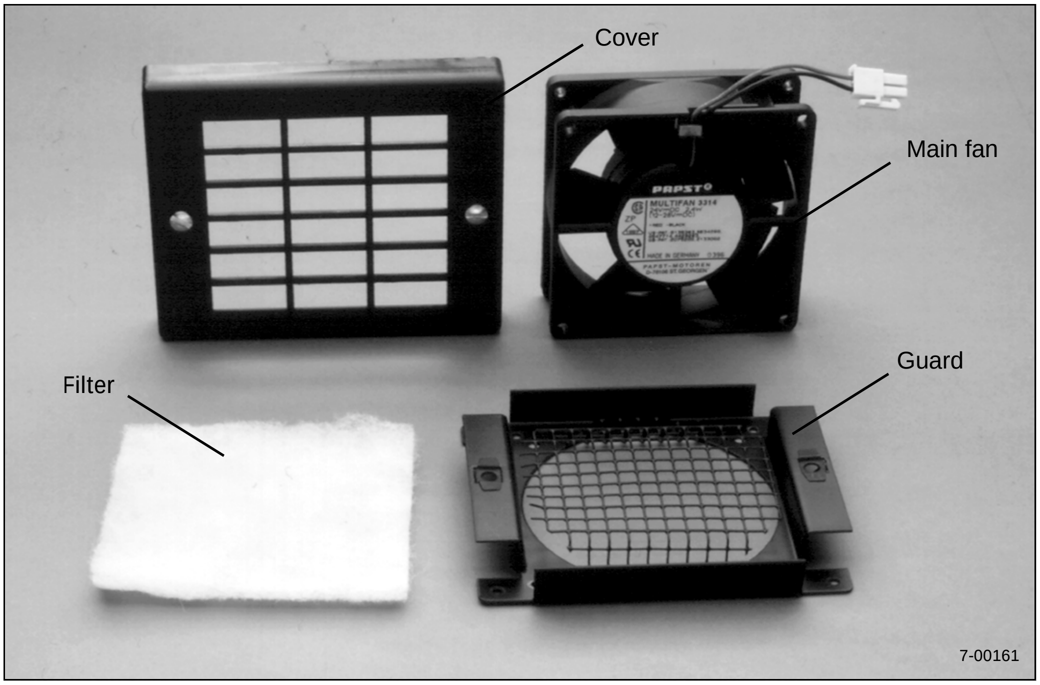

Cover
Main fan
Guard
Filter
7-00161

Figure 2-48. Main fan with cover, filter, and guard

2.3.7.4 Air flow thermistor assembly (Figure 2-49 and Figure 2-50)

The air flow thermistor assembly includes two thermistor beads, one mounted in the air flow and the other mounted in unmoving air. Readings from both thermistors are compared to determine whether air is flowing in the unit (whether the fan is operating and the fan filter is unclogged). (It is important that continuous air flow be maintained to prevent oxygen buildup inside the ventilator.) An insufficient air flow causes an alarm.

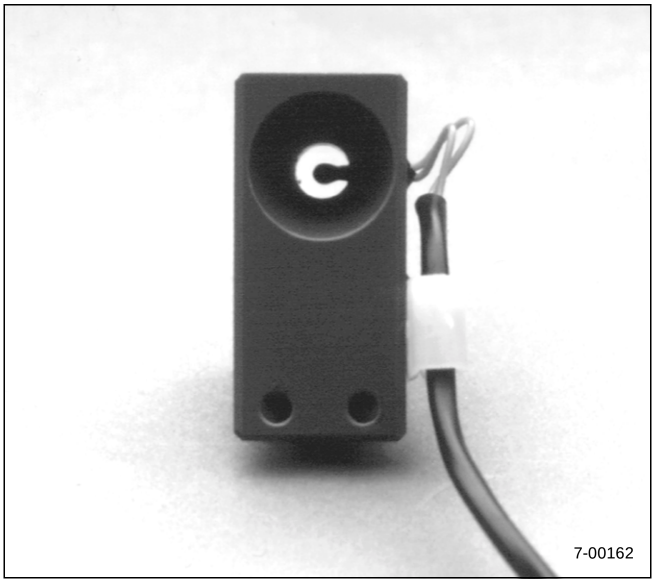


Figure 2-49. Air flow thermistor assembly

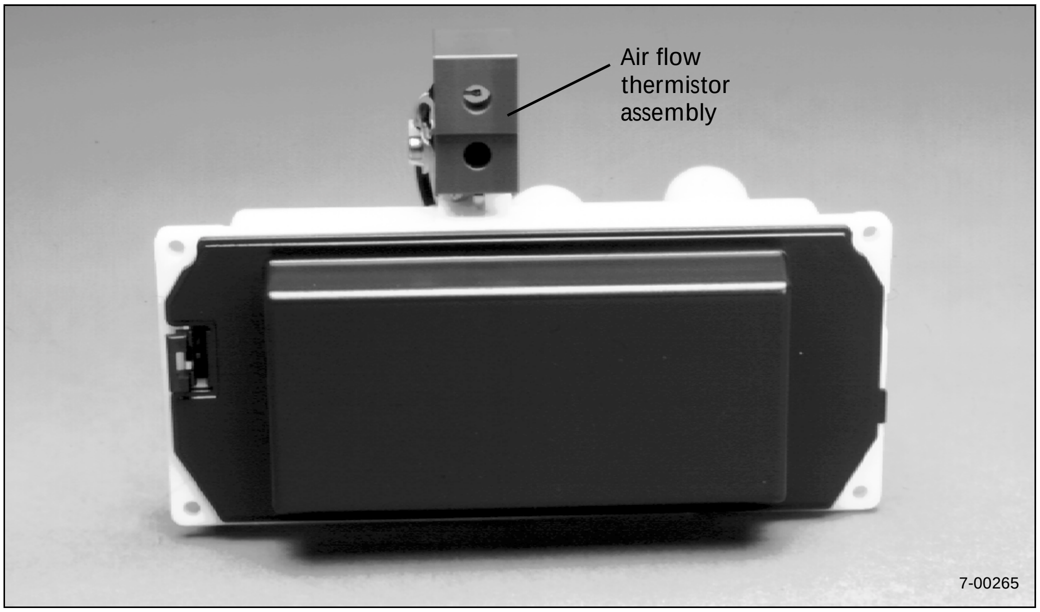


Figure 2-50. Air flow thermistor assembly installed on air intake manifold

2.3.7.5 Air intake filter switch (Figure 2-51 and Figure 2-47)

The air intake filter switch determines whether the air intake filter is installed. A tab on the filter engages this microswitch, which is located in the air intake filter manifold. If the air intake filter is not present, the AIR INTAKE ABSENT alarm is triggered.

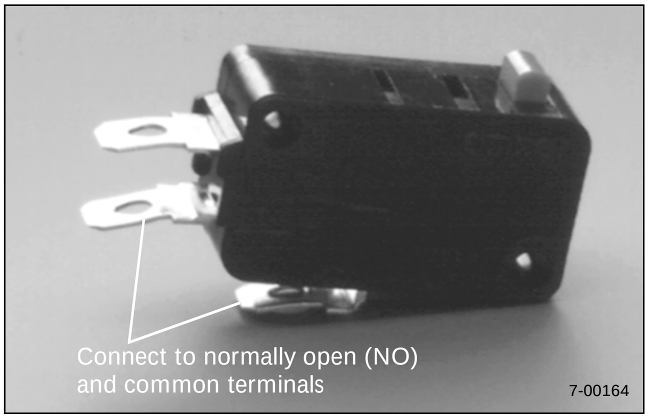


Figure 2-51. Air intake filter switch

2.4 Communications option

The addition of the communications option adds serial port configuration and upload/download enabling to the Service Menu. This applies to the *700 Series* Ventilators with software revision G or later. The communications option allows the ventilator to link to the following devices:

- The 6217 Remote Alarm
- The Nellcor Puritan Bennett *EasyNeb*™ Nebulizer
- A nurse call (or central station) device
- Up to two serial devices (such as a Nellcor Puritan Bennett *CliniVision*® System or other interactive device).

2.5 Motor control and drive (Figure 2-52)

The motor, which drives the piston back and forth, is controlled by the BD section of the controller PCB, including the motor controller circuit. Motor driver power circuits are on the BBU PCB.

Breath delivery parameters correspond to the following motor parameters:

- **Breath delivery phase -** Motor direction. Motor direction is sensed by the encoder.
- **Delivered volume -** Number of motor shaft rotations. Three rotations correspond to a 2.6 L volume displacement (or a 120 mm position displacement). Feedback from the encoder is used to determine piston position. See Section 2.2.1.1 for a description of encoder operation.
- **Patient pressure -** Motor torque. Applying the correct torque compensates for minor leaks and maintains the baseline at the correct level. Feedback from the cylinder pressure transducer helps maintain the cylinder pressure.

- **Flow -** Motor rotational velocity. The tachometer circuit on the pressure solenoid PCB provides a backup for the motor controller chipset.

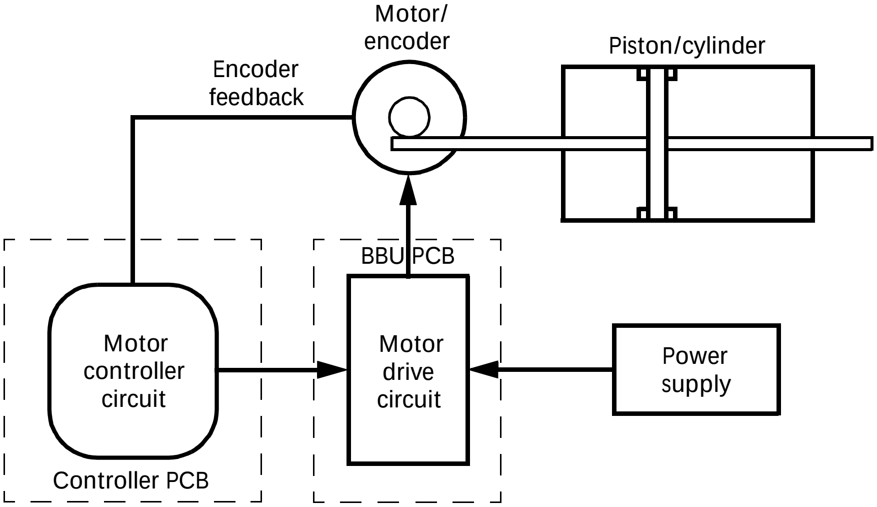


Figure 2-52. Motor control and drive

2.6 Breath delivery

The *700 Series Ventilator System* delivers mandatory (volume-controlled ventilation, VCV is available on the *740* and *760* Ventilators, and pressure-controlled ventilation, PCV, is available on the *760* Ventilator only) breaths and spontaneous (pressure support ventilation or PSV) breaths. Mandatory breaths are delivered in the assist/control (A/C) and synchronous intermittent mandatory ventilation (SIMV) modes. Spontaneous breaths are delivered in the spontaneous (SPONT) and SIMV modes. This section describes how the ventilator delivers mandatory and spontaneous breaths, from a hardware perspective.

Figure 2-53 is a plot showing ventilator parameters during the course of a mandatory VCV breath. Figure 2-54 shows ventilator parameters during a PCV breath. Consult the *700 Series Ventilator System Operator's Manual* for a clinical perspective.

Before the ventilator can deliver breaths, it must initialize the piston to determine the cylinder's leak and piston's position; this information is used for reference in breath delivery calculations. This initialization is also described below.

For detailed information about the motor control/drive operation, see Section 2.5.

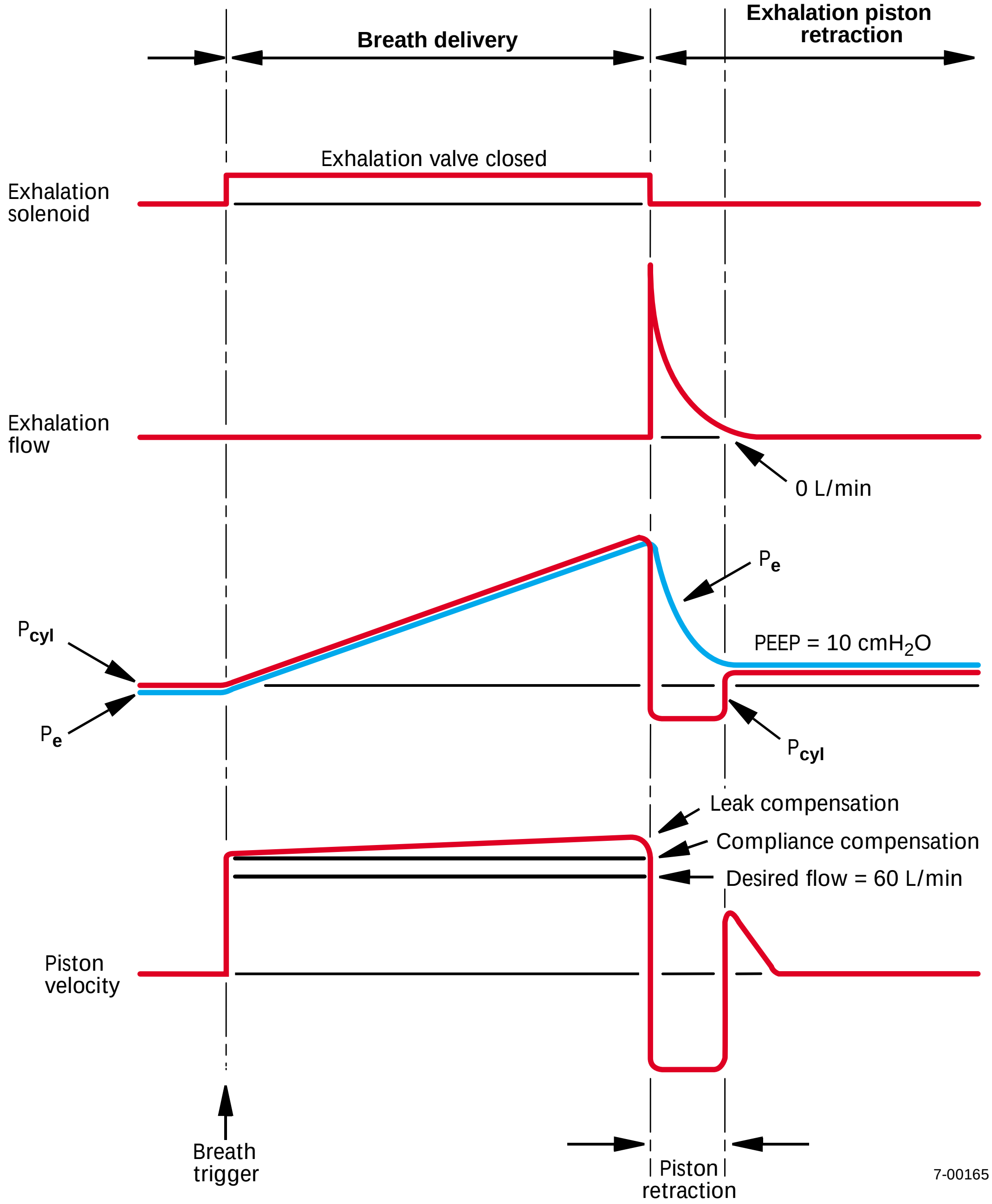

Breath delivery
Exhalation piston retraction
Exhalation valve closed
Exhalation solenoid
Exhalation flow
0 L/min
P_e
PEEP = 10 cmH_2O
P_{cyl}
P_e
P_{cyl}
Leak compensation
Compliance compensation
Desired flow = 60 L/min
Piston velocity
Breath trigger
Piston retraction
7-00165

Figure 2-53. Breath cycle for a VCV breath without PEEP

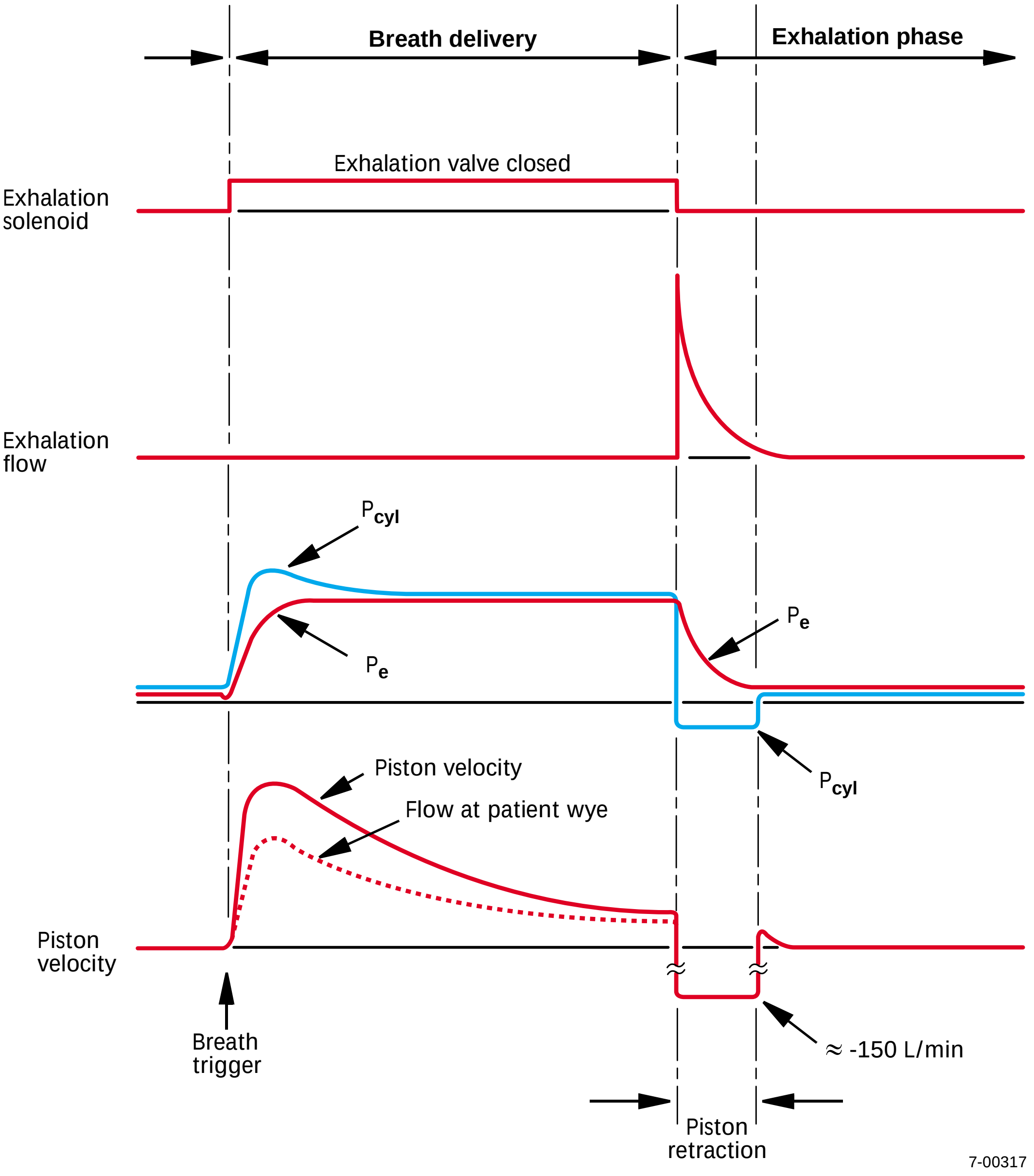

Breath delivery
Exhalation phase
Exhalation valve closed
Exhalation solenoid
Exhalation flow
Pcyl
Pe
Pe
Pcyl
Piston velocity
Flow at patient wye
Piston velocity
Breath trigger
≈ -150 L/min
Piston retraction
7-00317

Figure 2-54. Breath cycle for a PCV breath

2.6.1 Piston initialization (Figure 2-55)

During POST, the piston is initialized to determine its position; it is important that the ventilator know the piston's position before breath delivery begins. To initialize the piston, the ventilator drives the piston forward until the flag on the rack intercepts the end optoswitch. Then the piston is retracted until the flag intercepts the home optoswitch. Based on the number of quadrature counts ("quad counts") tallied by the motor controller circuit, the magnitude of the cylinder's stroke is determined. Now the piston is ready to deliver breaths.

The actual number of encoder counts between optoswitches is stored in NVRAM. The number counted during POST is compared with this number. If the counts measured during POST are within limits, then the test is passed; otherwise, POST fails.

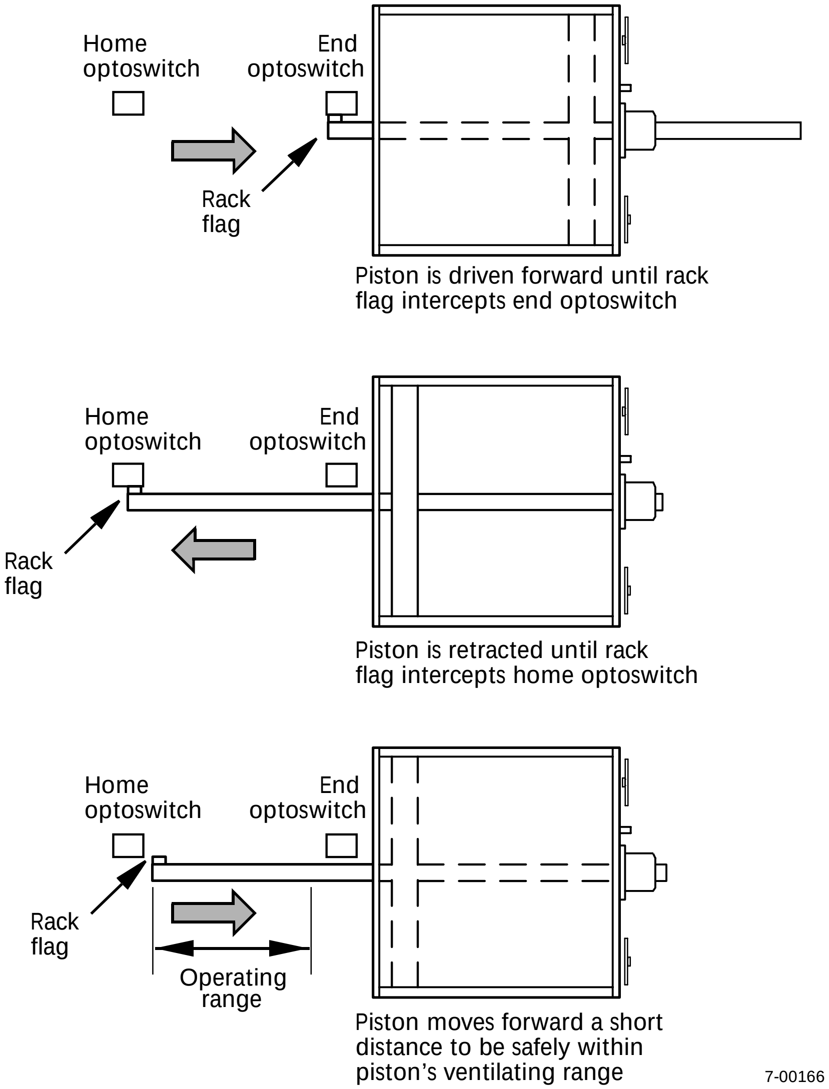

Home optoswitch
End optoswitch
Rack flag
Piston is driven forward until rack flag intercepts end optoswitch
Home optoswitch
End optoswitch
Rack flag
Piston is retracted until rack flag intercepts home optoswitch
Home optoswitch
End optoswitch
Rack flag
Operating range
Piston moves forward a short distance to be safely within piston's ventilating range
7-00166

Figure 2-55. Piston initialization

2.6.2 Breath triggering (Figure 2-56 and Figure 2-57)

On the *700 Series Ventilator System*, breaths can be ventilator-initiated, operator-initiated, and patient-initiated:

- A *ventilator-initiated breath* is triggered at an interval based on the RESPIRATORY RATE setting.
- An *operator-initiated breath* is triggered in response to the MANUAL INSPIRATION key being pressed.
- A *patient-initiated* breath is triggered when the ventilator senses patient effort. As shown in Figure 2-57, when patient effort begins, the exhalation pressure transducer measures a drop in pressure (P_e). As a result, the piston, which is constantly moving forward to maintain PEEP, speeds up to compensate for the pressure drop. When the piston velocity to maintain PEEP exceeds the operator-selected TRIGGER SENSITIVITY flow value (3 L/min in this case), the ventilator triggers into inspiration.

When a breath is triggered, the exhalation solenoid is energized, which causes the exhalation valve to be piloted closed.

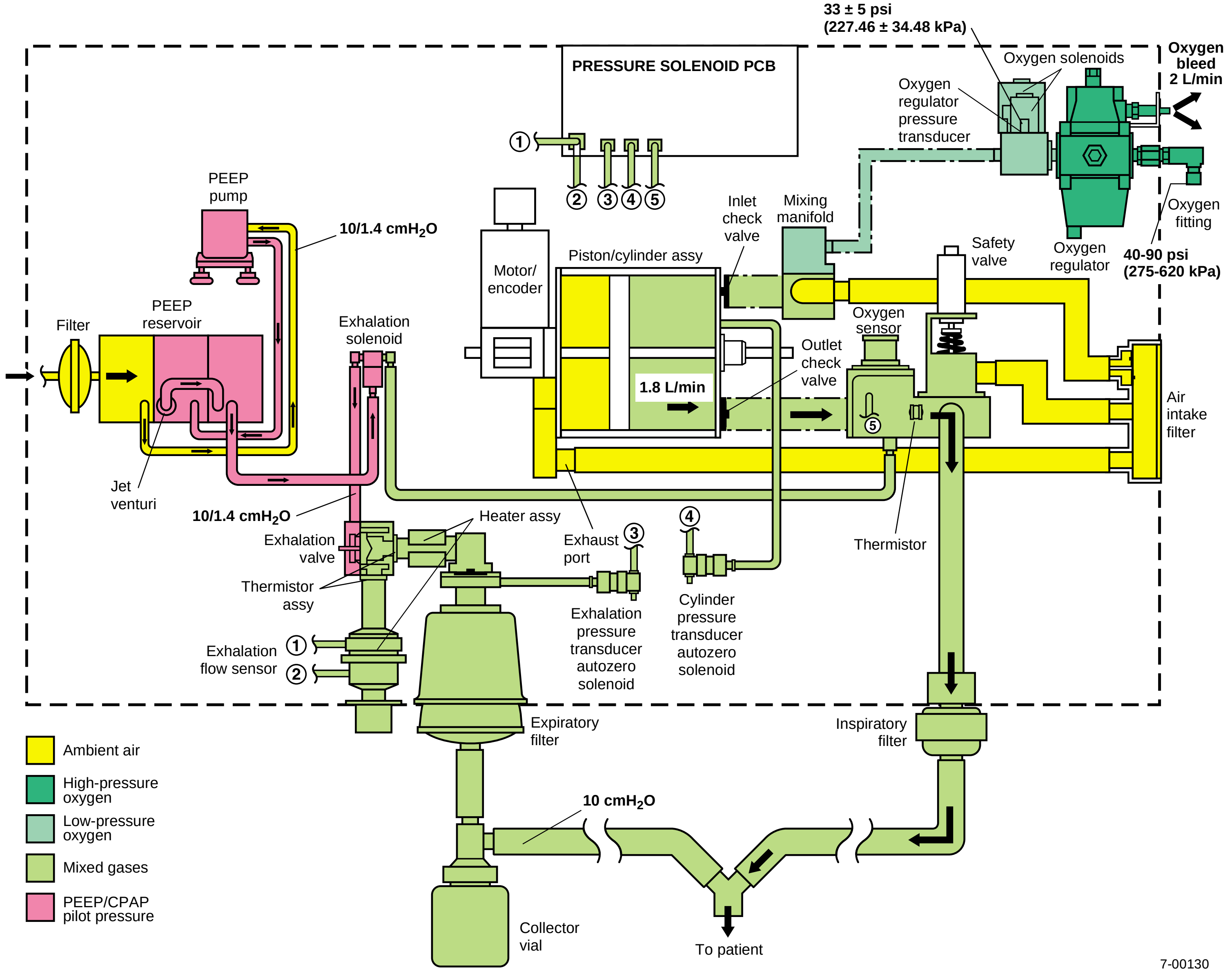

33 ± 5 psi
(227.46 ± 34.48 kPa)
PRESSURE SOLENOID PCB
Oxygen solenoids
Oxygen
bleed
2 L/min
Oxygen
regulator
pressure
transducer
①
②
③
④
⑤
PEEP
pump
10/1.4 cmH$_2$O
Inlet
check
valve
Mixing
manifold
Oxygen
fitting
Motor/
encoder
Piston/cylinder assy
Safety
valve
Oxygen
regulator
40-90 psi
(275-620 kPa)
PEEP
reservoir
Filter
Exhalation
solenoid
Oxygen
sensor
Outlet
check
valve
1.8 L/min
Air
intake
filter
⑤
Jet
venturi
10/1.4 cmH$_2$O
Heater assy
Exhalation
valve
Exhaust
port
③
④
Thermistor
Thermistor
assy
Exhalation
pressure
transducer
autozero
solenoid
Cylinder
pressure
transducer
autozero
solenoid
Exhalation
flow sensor
①
②
Expiratory
filter
Inspiratory
filter
10 cmH$_2$O
Collector
vial
To patient
🟨 Ambient air
🟩 High-pressure oxygen
🟩 Low-pressure oxygen
🟩 Mixed gases
🟥 PEEP/CPAP pilot pressure
7-00130

Figure 2-56. Pneumatic diagram of breath triggering

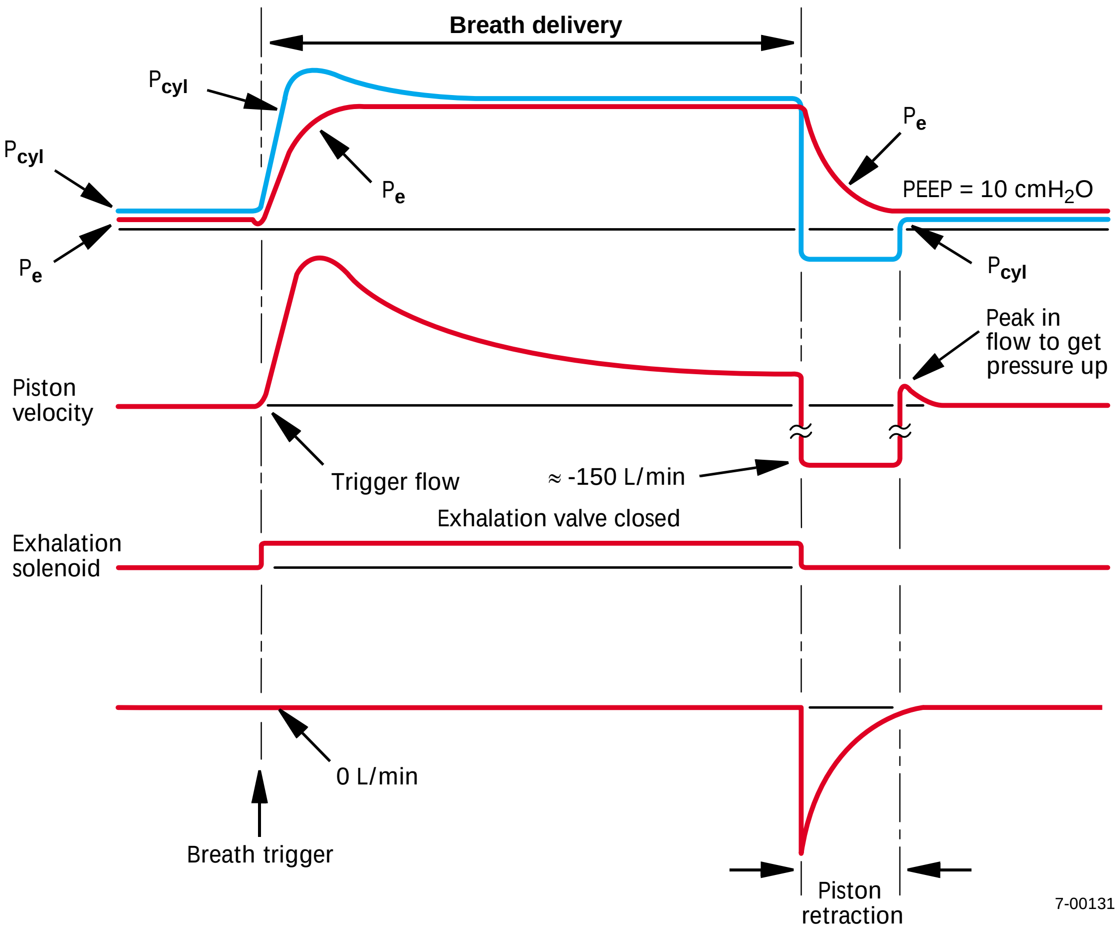


Figure 2-57. Breath triggering and breath delivery parameters

2.6.3 Gas delivery to the patient (Figure 2-57 and Figure 2-58)

After the breath is triggered, the piston moves forward, expelling the cylinder's contents.

In a PSV breath, the piston's speed, force, and size of excursion are determined by the patient's demands and ventilator settings. In a VCV breath, the piston's velocity is determined by the PEAK FLOW setting with flow added to compensate for piston/ cylinder leak and compliance. In a PCV breath, the piston's velocity is determined by the RISE TIME FACTOR and INSP IRATORY PRESSURE settings. On the *760* Ventilator, delivered volume is displayed during PSV and PCV breaths, and is calculated based on piston/cylinder displacement, minus losses due to cylinder leak, tubing compliance, and piston/cylinder compliance.

In a VCV breath, the patient receives a square flow waveform. The piston velocity waveform for a VCV breath, however, shows a slight ramp. This is because the increasing cylinder pressure creates a greater leak in the cylinder, requiring additional leak compensation. In a PCV breath, the flow waveform is determined by the selected INSPIRATORY PRESSURE and RISE TIME FACTOR settings (as cylinder pressure increases, the leak and required compensation also increase).

Gas flows through the inspiration manifold to the ventilator outlet. Throughout breath delivery, the inspiration gas pilots the exhalation valve closed.

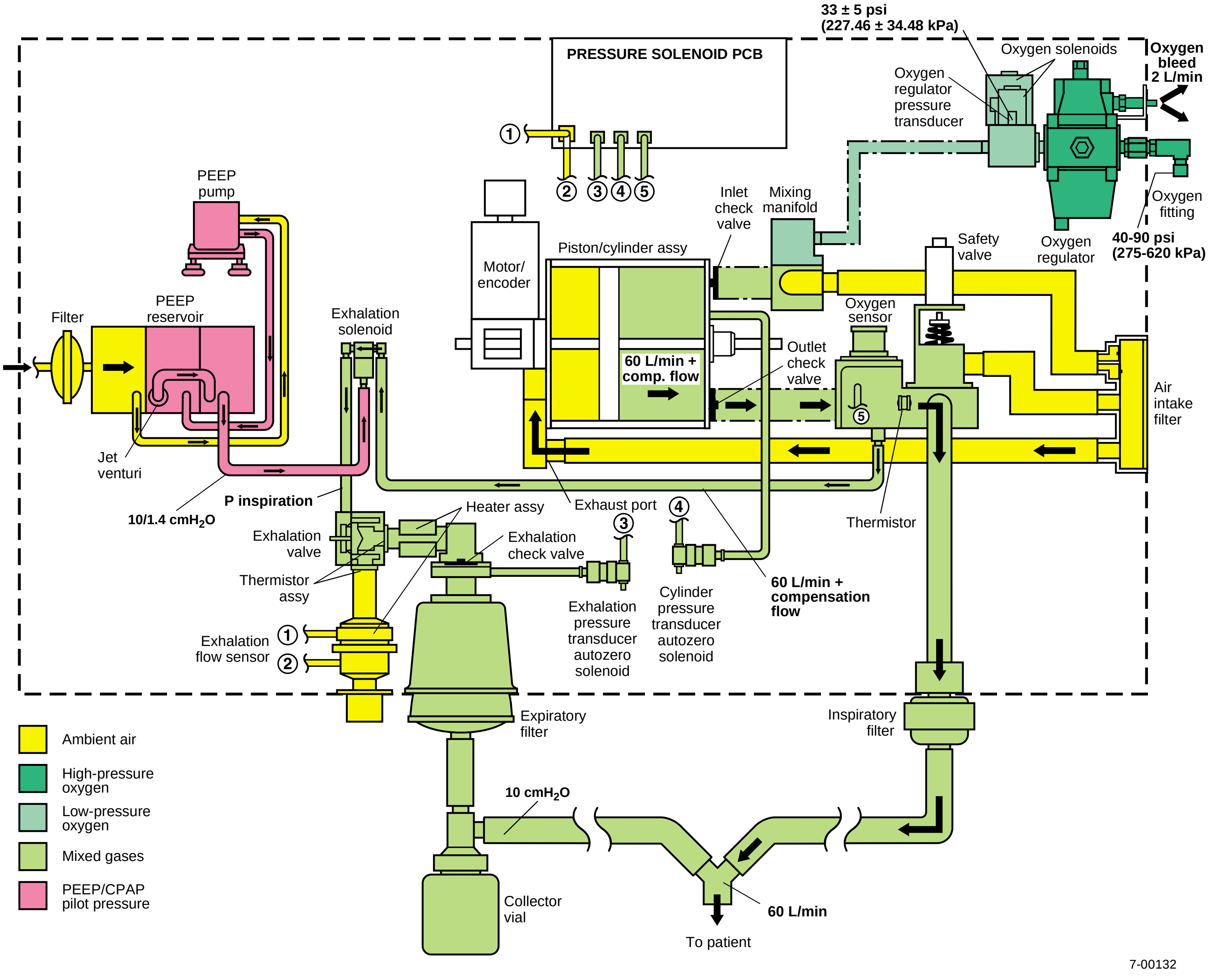

33 ± 5 psi
(227.46 ± 34.48 kPa)
PRESSURE SOLENOID PCB
Oxygen solenoids
Oxygen bleed 2 L/min
Oxygen regulator pressure transducer
①
②
③
④
⑤
PEEP pump
Inlet check valve
Mixing manifold
Oxygen fitting
Motor/ encoder
Piston/cylinder assy
Safety valve
Oxygen regulator
40-90 psi
(275-620 kPa)
PEEP reservoir
Filter
Exhalation solenoid
Oxygen sensor
60 L/min + comp. flow
Outlet check valve
⑤
Air intake filter
Jet venturi
10/1.4 cmH₂O
P inspiration
Heater assy
Exhaust port
④
③
Thermistor
Exhalation valve
Exhalation check valve
Thermistor assy
60 L/min + compensation flow
Exhalation pressure transducer autozero solenoid
Cylinder pressure transducer autozero solenoid
Exhalation flow sensor
①
②
Expiratory filter
Inspiratory filter
10 cmH₂O
Collector vial
60 L/min
To patient
7-00132
Ambient air
High-pressure oxygen
Low-pressure oxygen
Mixed gases
PEEP/CPAP pilot pressure

Figure 2-58. Pneumatic diagram of gas delivery

Pressures on both the inspiration and exhalation sides of the ventilator breathing circuit are measured by the cylinder, inspiration, and exhalation pressure transducers during gas delivery. They are used in breath delivery calculations.

During gas delivery, the oxygen side remains pressurized, but there is no flow, as the oxygen solenoids are de-energized.

2.6.4 Exhalation and piston retraction (Figure 2-59 and Figure 2-60)

In a mandatory/assist VCV breath, exhalation is declared when the full volume is delivered and any plateau period has ended. In a mandatory/assist PCV breath, exhalation is declared when the selected inspiratory pressure has been delivered for the set inspiratory time. In spontaneous breathing, exhalation is declared when an inspiratory pressure, flow, or time threshold is reached. During the exhalation phase, these two actions occur simultaneously:

- The patient exhales through the opened exhalation valve.
- The cylinder is filled in preparation for the next breath.

2.6.4.1 Exhalation

When exhalation is declared, the exhalation solenoid is de-energized, supplying PEEP pilot pressure to pilot the exhalation valve to the operator-selected PEEP level, if any. The patient can now exhale through the exhalation assembly. The gas is routed through the exhalation flow sensor before being vented. Spirometry measurements are made by the exhalation flow sensor.

2.6.4.2 Piston retraction

While the patient exhales, the cylinder is filled with gas in preparation for the next breath. To fill the cylinder, the ventilator retracts the piston to its home position at a rate equivalent to 150 L/min at a minimum. After it reaches home, the piston may move forward continuously to maintain PEEP. During retraction, the ventilator energizes one of the oxygen solenoids if required. The piston retraction causes the cylinder pressure to fall, which causes air and/or oxygen to be drawn into the cylinder.

2.6.4.2.1 An oxygen percentage of 21 is selected (Figure 2-61)

The cylinder is filled with room air. As the piston retracts, the negative pressure in the cylinder draws in ambient room air.

2.6.4.2.2 An oxygen percentage greater than 21 is selected (Figure 2-61)

The cylinder is filled with a combination of room air and oxygen. Two solenoids, the high- and low-flow oxygen solenoids, control the flow of oxygen toward the cylinder. One of the solenoids is energized during a breath. The high-flow solenoid, which can deliver greater than 150 L/min through its orifice, is used when a larger volume of oxygen is required. The low-flow oxygen solenoid, which can deliver 15 L/min through its orifice, is used when a smaller volume of oxygen is required.

The volume of oxygen needed to obtain the correct air/oxygen mixture is determined from the calculated retraction volume. Each orifice can deliver a specific oxygen flow. If it would take less than 30 ms to deliver the required oxygen volume through the high-flow orifice, the low-flow solenoid/orifice is used. If it would take more than 30 ms to deliver the oxygen volume through the high-flow orifice, the high-flow solenoid/orifice is used. Typically, the high-flow solenoid is used when greater than 30% oxygen is selected, and the low-flow solenoid is used when less than 30% oxygen is selected.

If the high-flow solenoid is chosen, this solenoid is energized during the first part of the retraction period. Oxygen flows through the high-low orifice at 150 L/min, through the manifold, and into the cylinder (which is retracting at a minimum of 150 L/min). During the second part of the retraction period, the oxygen solenoid is de-energized, and only room air flows into the cylinder as the piston retracts.

If the low-flow solenoid is chosen, this solenoid is energized during the first part of the retraction period. Oxygen flows through the low-flow orifice at 15 L/min, through the manifold, and into the cylinder. Because the piston is retracting at a minimum of 150 L/min, room air simultaneously flows through the manifold and into the cylinder to augment the low oxygen flow. During the second part of the retraction period, the oxygen solenoid is de-energized, and only room air flows into the cylinder as the piston retracts.

If 100% oxygen is selected, the high-flow solenoid is energized during the entire retraction period. Oxygen flows through the high-flow orifice at 150 L/min, and room air does not enter the cylinder.

2.6.4.3 Mandatory breathing with delivered volumes less than 250 mL

(Figure 2-62)

In mandatory breathing, when the volume of gas being delivered is less than 250 mL (a combination of base flow and leak compensation), the piston may not retract with each breath. Because the cylinder holds enough gas to deliver more than one such breath, the piston makes a small excursion forward to deliver a breath, retracts to the PEEP level, then makes another small excursion forward to deliver another breath. It only retracts completely for filling when insufficient gas remains to deliver the next breath.

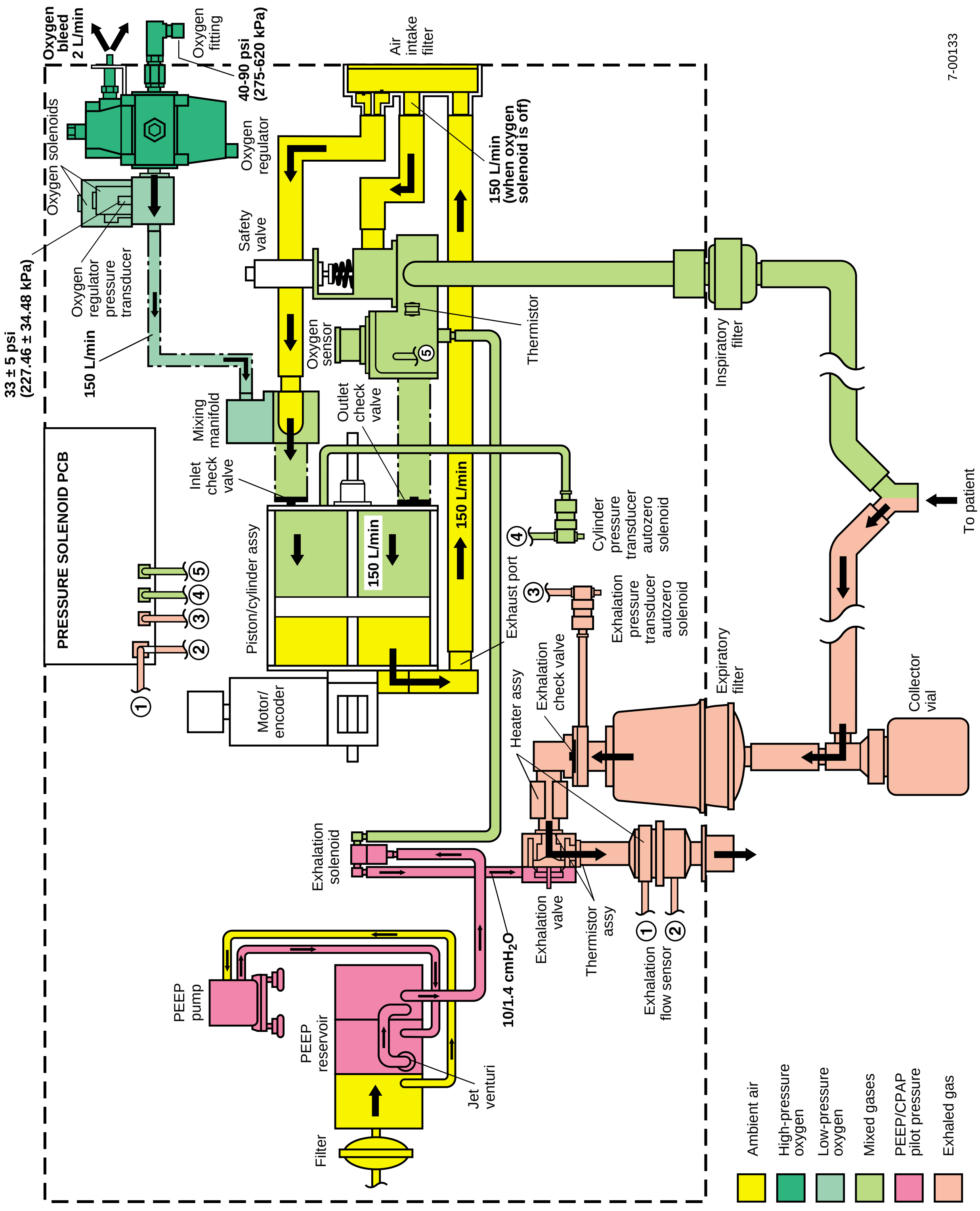

33 ± 5 psi
(227.46 ± 34.48 kPa)
150 L/min
Oxygen regulator pressure transducer
Oxygen solenoids
Oxygen bleed 2 L/min
Oxygen fitting
40-90 psi (275-620 kPa)
Oxygen regulator
Safety valve
PRESSURE SOLENOID PCB
①
②
③
④
⑤
Mixing manifold
Inlet check valve
Piston/cylinder assy
Motor/ encoder
Oxygen sensor
Outlet check valve
150 L/min
150 L/min
Air intake filter
150 L/min (when oxygen solenoid is off)
Thermistor
Exhaust port
④
Cylinder pressure transducer autozero solenoid
③
Exhalation pressure transducer autozero solenoid
Exhalation check valve
Heater assy
Exhalation solenoid
PEEP pump
PEEP reservoir
Filter
Jet venturi
10/1.4 cmH₂O
Exhalation valve
Thermistor assy
Exhalation flow sensor ① ②
Expiratory filter
Inspiratory filter
Collector vial
To patient
Ambient air
High-pressure oxygen
Low-pressure oxygen
Mixed gases
PEEP/CPAP pilot pressure
Exhaled gas
7-00133

Figure 2-59. Pneumatic diagram of exhalation and piston retraction (low-flow oxygen solenoid energized)

When the exhalation valve opens, P_e falls, then is maintained at PEEP.

When the inspiratory time has passed, exhalation is triggered. The exhalation solenoid is de-energized, opening the exhalation valve.

When the exhalation valve is opened, exhaled flow is recorded.

Piston retraction begins once exhalation is declared. In this case the high-flow oxygen solenoid is energized, causing a slight dip in oxygen source pressure. During the first part of the retraction period, oxygen, flowing at 150 L/min, enters the cylinder, which is also retracting at -150 L/min. During the second part of the retraction period, room air is drawn in at 150 L/min, creating an air/oxygen mixture of 61%.

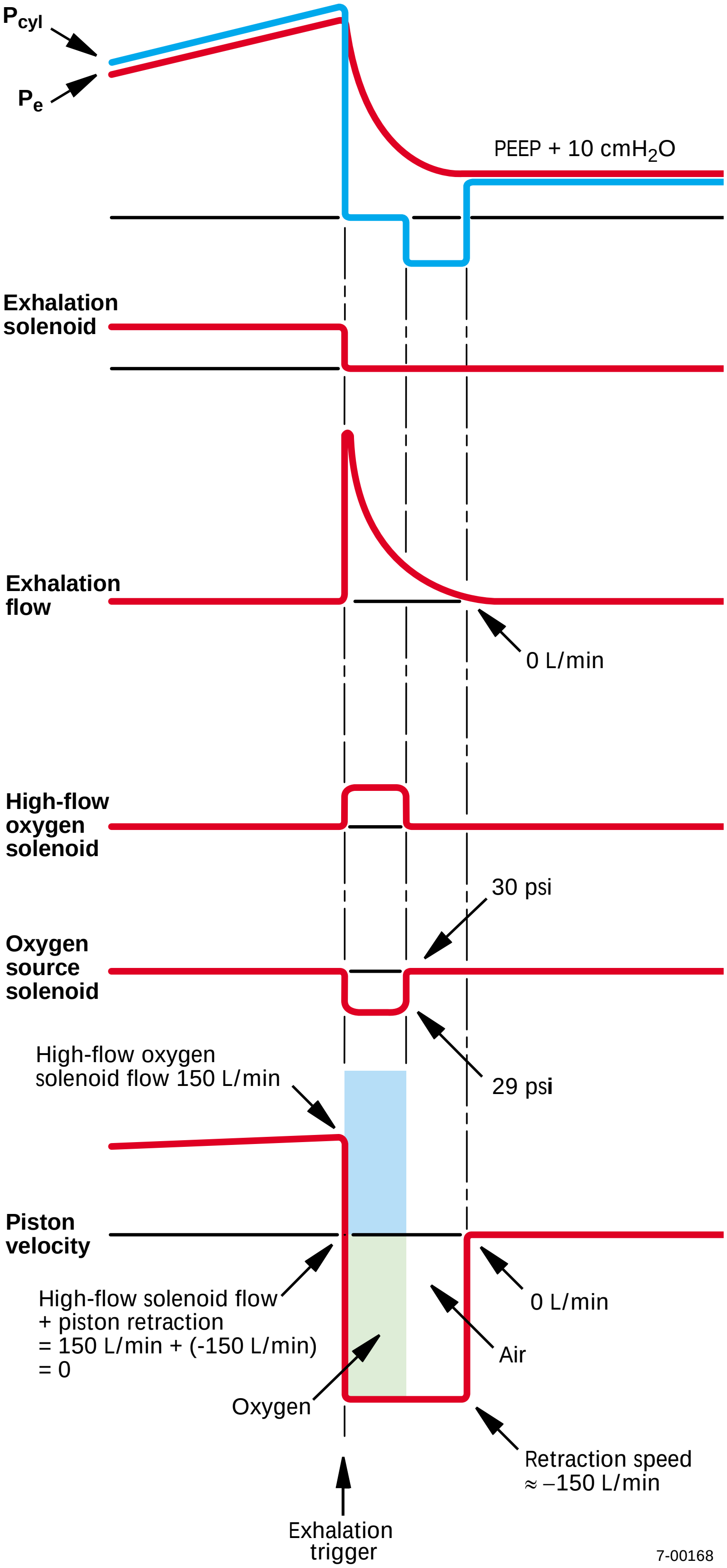


Figure 2-60. Exhalation and piston retraction parameters

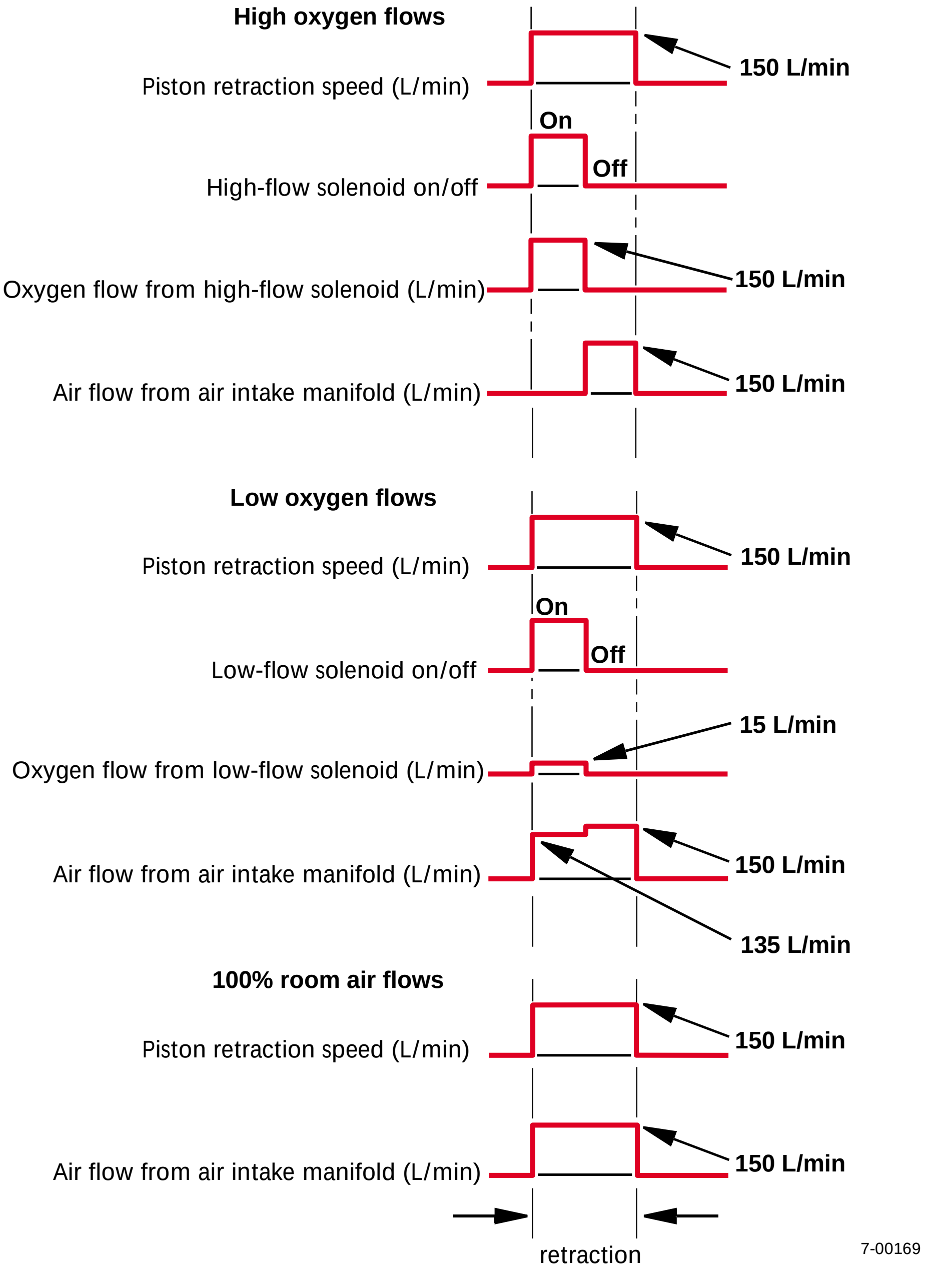
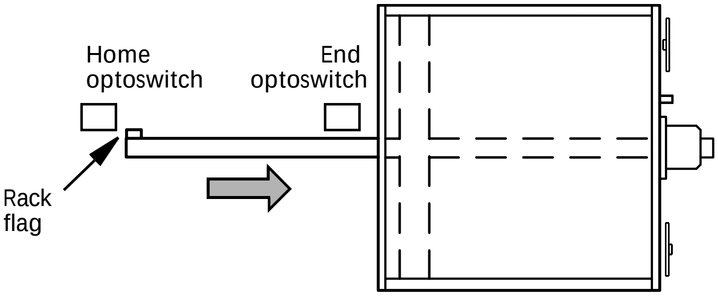
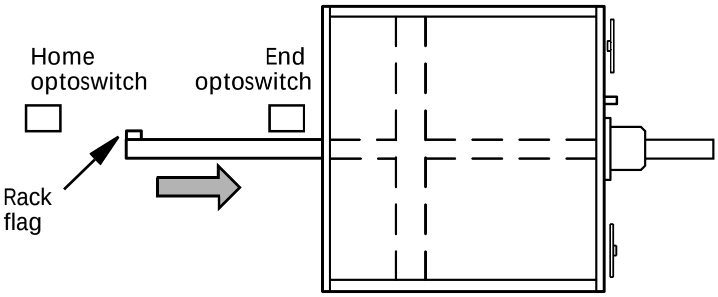

High oxygen flows
Piston retraction speed (L/min)
150 L/min
On
Off
High-flow solenoid on/off
Oxygen flow from high-flow solenoid (L/min)
150 L/min
Air flow from air intake manifold (L/min)
150 L/min
Low oxygen flows
Piston retraction speed (L/min)
150 L/min
On
Off
Low-flow solenoid on/off
15 L/min
Oxygen flow from low-flow solenoid (L/min)
Air flow from air intake manifold (L/min)
150 L/min
135 L/min
100% room air flows
Piston retraction speed (L/min)
150 L/min
Air flow from air intake manifold (L/min)
150 L/min
retraction
7-00169

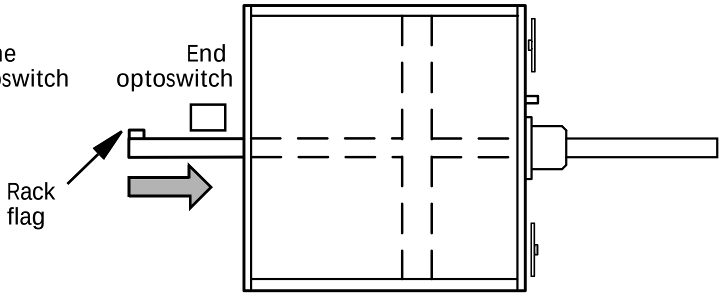
Figure 2-61. Air and oxygen flow during retraction


Home optoswitch
End optoswitch
Rack flag

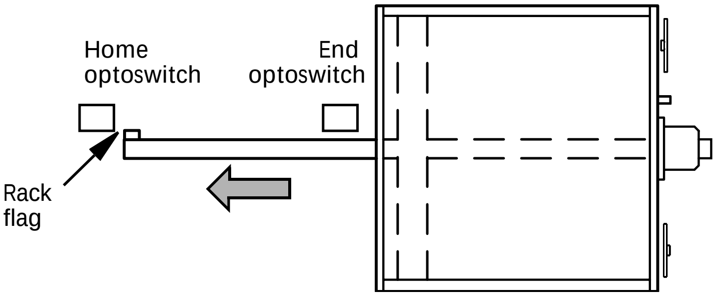
Piston starts at home position


Home optoswitch
End optoswitch
Rack flag

Piston makes a small excursion to deliver a breath


Home optoswitch
End optoswitch
Rack flag

Piston makes another small excursion to deliver a second breath


Home optoswitch
End optoswitch
Rack flag

Piston returns to home position when insufficient gas remains to deliver another breath

7-00170

Figure 2-62. Piston movement for volumes <250 ml

2.7 Power source switchover (Figure 2-63)

The *700 Series Ventilator System* normally operates from ac (mains) power, but it switches to battery operation if necessary. The ventilator switches to battery operation in these instances:

- The +24 V power supply output is <21 V.
- At power on (The ventilator operates from battery for the first 3 seconds, before switching to ac).

The battery backup circuit on the BBU PCB monitors the +24 V power supply output and the internal and external battery outputs. Normal ventilation can proceed if one of these outputs is at least +21 V. The ventilator's first choice is to operate from the power supply output, then the external battery, and then the internal battery. Before operating from the power supply, however, the circuit verifies that the power supply output is stable and remains stable for 3 seconds. This means that for the first 3 seconds after the ventilator power is turned on, the ventilator is powered from the external (if available and charged) or internal battery. After 3 seconds, provided the power supply output is determined to be acceptable, the ventilator switches from operating from the battery to operating from the power supply.

If ac power is restored after the ventilator has switched to battery, the ventilator again verifies that the power supply output is stable for 3 seconds before resuming ac power operation.

If none of the three power sources is acceptable, the battery monitoring circuit on the BBU PCB signals the controller PCB, which attempts an orderly shutdown of the ventilator circuits. Various ventilator circuits are initialized (put into known states. Because critical ventilator data is stored in NVRAM, which has its own battery, this data is not lost.) The ventilator invokes the safety valve (SVO) open state (see next subsection). When the batteries are being charged, the ON AC/ BATTERY CHARGING LED is lit. When the ventilator is operating from the battery power, the ON INTERNAL BATTERY or ON EXTERNAL BATTERY LED flashes.

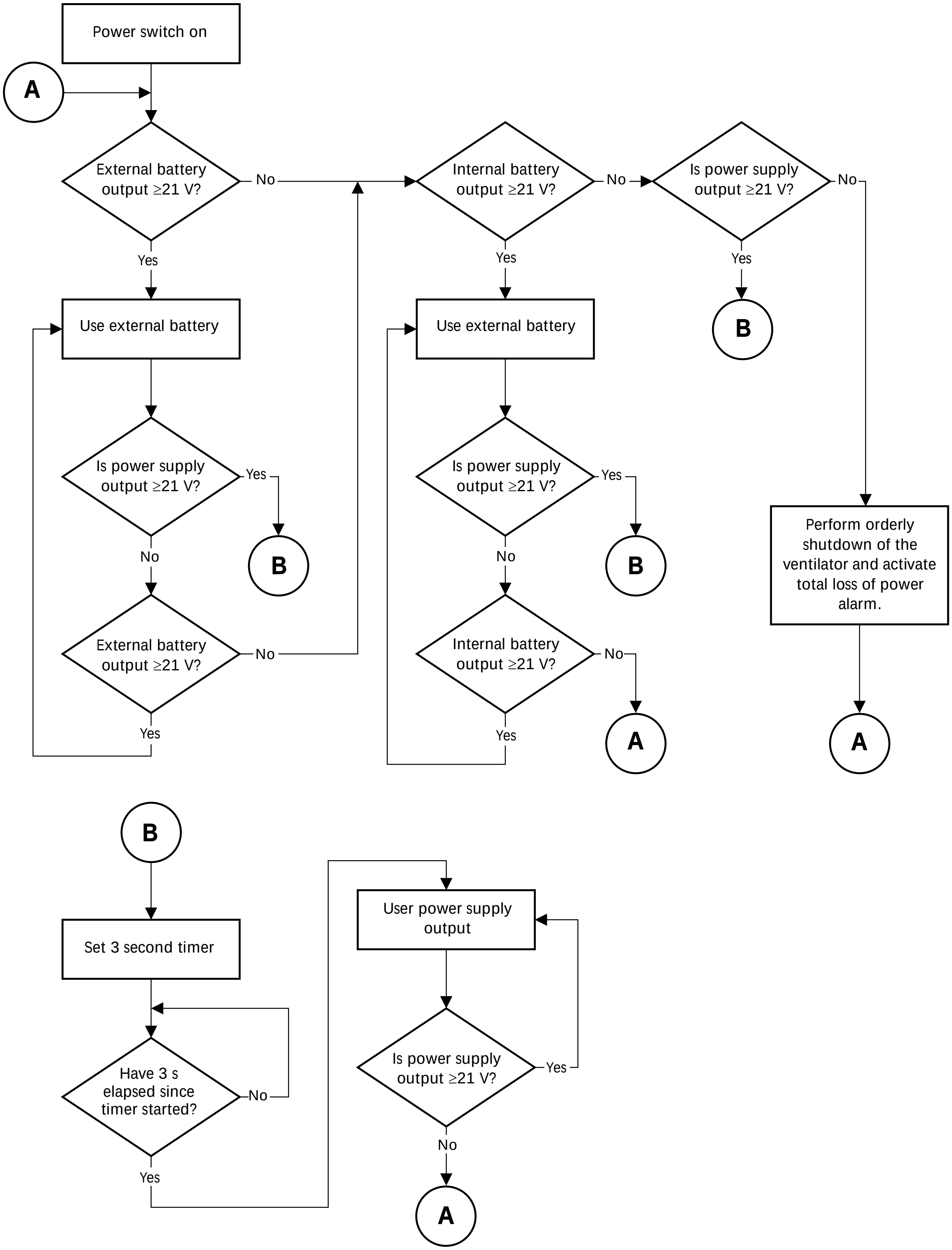

Power switch on
A
External battery output ≥21 V?
No
Yes
Use external battery
Is power supply output ≥21 V?
Yes
B
No
External battery output ≥21 V?
No
Yes
Internal battery output ≥21 V?
No
Yes
Use external battery
Is power supply output ≥21 V?
Yes
B
No
Internal battery output ≥21 V?
No
A
Yes
Is power supply output ≥21 V?
No
Yes
B
Perform orderly shutdown of the ventilator and activate total loss of power alarm.
A
B
Set 3 second timer
Have 3 s elapsed since timer started?
No
Yes
User power supply output
Is power supply output ≥21 V?
Yes
No
A
7-00134

Figure 2-63. Power source switchover

2.8 Emergency modes

This section describes how the ventilator operates under several unexpected conditions, including occlusion cycling mode, a ventilator inoperative (VENT INOP) condition, and when the ventilator opens the safety valve.

2.8.1 Occlusion cycling mode

If the ventilator detects an occlusion in the ventilator breathing circuit or a continuous high inspiratory pressure condition (due to an exhalation valve that does not open or an occluded flow sensor), it opens the safety and exhalation valves to vent excess pressure, then shuts them and begins *occlusion cycling mode*. In occlusion cycling mode the ventilator uses current settings except for the following, if applicable (Table 2-3):

Table 2-3: Changes to current settings in occlusion cycling mode

Setting	Change to setting in occlusion cycling mode
% O_2 (all modes)	Set to 100%.
PEEP (all modes)	Set to 0 cmH_2O.
RISE TIME FACTOR (A/C PCV, SIMV PCV, and SPONT PSV, *760* Ventilator only)	Set to 70.
SPONT mode	Patient-initiated breath triggering disabled, PSV breaths delivered at a rate of 12/min with an inspiratory time of 2 seconds.
INSPIRATORY PRESSURE (A/C PCV and SIMV PCV)	If less than 15 cmH_2O: set to 15 cmH_2O. If 15 cmH_2O or above: the current setting is used (no change).
SUPPORT PRESSURE (SPONT PSV)	If less than 15 cmH_2O: set to 15 cmH_2O. If 15 cmH_2O or above: the current setting is used (no change).
HIGH PRESSURE alarm (A/C VCV)	If greater than 30 cmH_2O: set to 30 cmH_2O. If 30 cmH_2O or less: the current setting is used (no change).
HIGH PRESSURE alarm (A/C PCV)	Set to INSPIRATORY PRESSURE (as adjusted for occlusion cycling mode) + 20 cmH_2O, up to a maximum of 90 cmH_2O.
HIGH PRESSURE alarm (SIMV VCV)	If greater than 30 cmH_2O, set to whichever is greater: • 30 cmH_2O, or • SUPPORT PRESSURE + 2 cmH_2O If 30 cmH_2O or less, set to whichever is greater: • the current setting (no change), or • SUPPORT PRESSURE + 2 cmH_2O.

Table 2-3: Changes to current settings in occlusion cycling mode (continued)

Setting	Change to setting in occlusion cycling mode
HIGH PRESSURE alarm (SIMV PCV)	Set to whichever is greater: • INSPIRATORY PRESSURE (as adjusted for occlusion cycling mode) + 20 cmH_2O, up to a maximum of 90 cmH_2O, or • SUPPORT PRESSURE + 2 cmH_2O.
HIGH PRESSURE alarm (SPONT PSV)	SUPPORT PRESSURE (as adjusted for occlusion cycling mode) + 20 cmH_2O, up to a maximum of 90 cmH_2O.
PCV apnea INSPIRATORY PRESSURE (*760* Ventilator only)	If 15 cmH_2O or greater, set to whichever is less: • the current setting (no change), or • HIGH PRESSURE alarm setting (adjusted for occlusion cycling mode) - 2 cmH_2O. If less than 15 cmH_2O, set to whichever is less: • 15 cmH_2O, or • HIGH PRESSURE alarm setting (adjusted for occlusion cycling mode) - 2 cmH_2O.

If the ventilator again detects an occlusion or continuous high pressure condition, it again opens the safety and exhalation valves then resumes occlusion cycling mode. If the operator presses the alarm reset key or the ventilator does not detect an occlusion or continuous high pressure condition for two consecutive breaths, it reverts to normal ventilation using the most recently accepted settings.

2.8.2 Ventilator inoperative

When either the BD or UI microprocessor determines it cannot properly ventilate the patient, it declares a *ventilator inoperative* (VENT INOP) condition.

2.8.2.1 When the VENT INOP condition is triggered

The VENT INOP condition is triggered in these cases:

- After a hardware test (POST, EST, or ongoing checks) fails, if the hardware failure could compromise safe ventilation.
- After three software errors are detected during 24 operational hours.
- If inspiration manifold temperature falls below 5 °C.

2.8.2.2 How the ventilator responds to a VENT INOP condition

When a VENT INOP condition is declared, the ventilator goes into the safety valve open (SVO) state, the motor drive circuit is disabled, the VENT INOP indicator is lit, and the main or backup alarm sounds, depending on the severity of the triggering condition.

2.8.2.3 How to clear the VENT INOP condition

To clear the VENT INOP condition, you must repair the ventilator and run and pass all EST tests before ventilation can resume. To do so, first cycle power to the ventilator. The ventilator will now let you access a limited set of service menu functions only (see Section 4), including the EST function.

2.8.3 Safety valve open (SVO)

The ventilator's safety valve provides a way for the patient to breathe unassisted in cases where a hardware or software failure might compromise safe ventilation. In most such cases (except where the UI and BD microprocessors are unable to control the safety valve due to a malfunction), the UI or BD microprocessor places the ventilator into the safety valve open (SVO) state. Figure 2-64 is a pneumatic diagram showing the ventilator in the SVO state.

The SVO state involves these actions:

- The safety valve solenoid is de-energized under control of the UI or BD microprocessor, causing the safety valve to open, so the patient can breathe room air.
- The SAFETY VALVE OPEN indicator is lit and the alarm is sounded.
- The PEEP pump drive is disabled, causing the exhalation solenoid to be de-energized. This results in the exhalation valve being opened.
- The drive to the motor/encoder is disabled, reducing the circuit pressure to zero.

The SVO state can also be triggered by a backup hardware circuit on the pressure solenoid PCB. If neither microprocessor is able to control the safety valve, the backup circuit opens the safety valve when pressure exceeds 115 cmH_2O. Table 2-4 summarizes the events that cause the safety valve to open.

Table 2-4: Safety valve open causes and indications

Trigger	Audio alarm	Status indicators	Notes
Ventilator inoperative condition (including patient system pressure exceeded 92 cmH_2O)	Backup alarm (possibly main alarm)	SAFETY VALVE OPEN VENT INOP ALARM (solid or flashing)	Hardware failure (pressure sensor or pressure sensing circuit, motor, memory, microprocessor, or dc power failure; inspiration manifold temperature < 5 ^oC; or three software resets in 24 operational hours) resulted in software declaring a VENT INOP condition.
Patient system pressure exceeded 115 cmH_2O	Indeterminate	SAFETY VALVE OPEN	Safety valve was opened by backup circuit on pressure solenoid PCB. Valve should have been opened by primary, microprocessor-controlled circuit at 92 cmH_2O.
Occlusion	Main alarm	SAFETY VALVE OPEN ALARM (flashing)	Safety valve opens and closes to relieve pressure.
POST execution	Both main and backup alarms for a time	SAFETY VALVE OPEN	Because the ventilator's functionality is unknown until POST is completed, the safety valve remains open (de-energized) during POST.

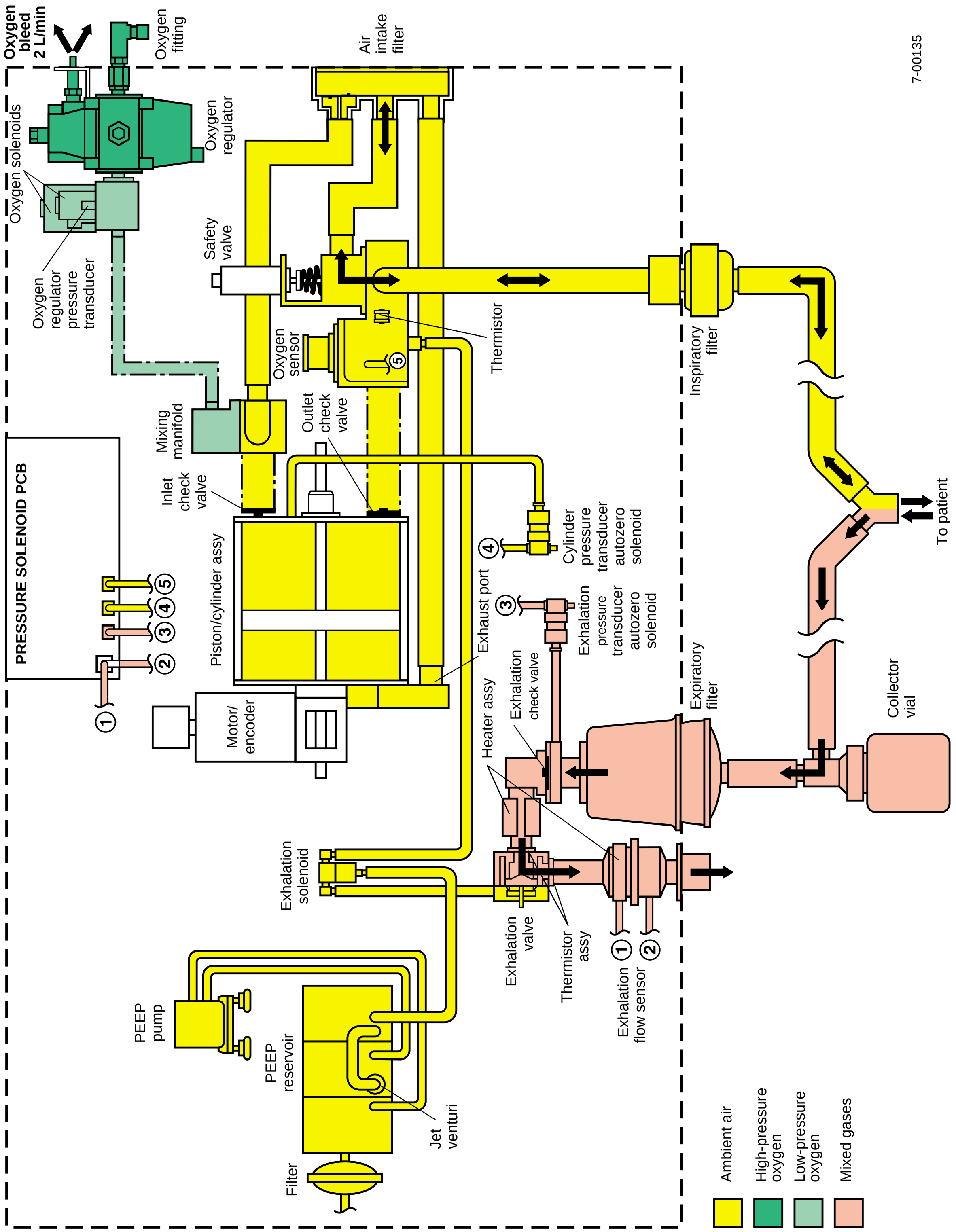

PRESSURE SOLENOID PCB
①
②
③
④
⑤
Oxygen solenoids
Oxygen bleed 2 L/min
Oxygen regulator pressure transducer
Oxygen fitting
Oxygen regulator
Mixing manifold
Inlet check valve
Safety valve
Air intake filter
Oxygen sensor
Outlet check valve
Piston/cylinder assy
Motor/ encoder
PEEP pump
PEEP reservoir
Filter
Jet venturi
Exhalation solenoid
Exhaust port
Thermistor
Heater assy
Exhalation check valve
Exhalation valve
Thermistor assy
Exhalation flow sensor
Exhalation pressure transducer autozero solenoid
Cylinder pressure transducer autozero solenoid
Expiratory filter
Inspiratory filter
To patient
Collector vial
Ambient air
High-pressure oxygen
Low-pressure oxygen
Mixed gases
7-00135

Figure 2-64. Safety valve open pneumatic diagram

SECTION

3

Self-tests

This section describes the *700 Series Ventilator System*’s built-in self-tests, including how to run them. It also describes how the ventilator responds when the self-tests detect undesirable conditions. For a listing of ventilator diagnostic codes, refer to Section 6. For a listing of alarm messages, refer to Section 7.

3.1 Introduction

The *700 Series Ventilator System* has the self-test capabilities described in Table 3-1.

Table 3-1: Self-tests

Name	Purpose	When it is run
Power-on self-test (POST)	Verifies the integrity of the microcontrollers, power supply, battery, transducers, and motor.	Automatically • when power is applied to the ventilator (including after a power interruption) • at the start and end of SST and EST • when exiting from standby mode or calibration • after pressure units are changed (utility menu function) • after the ventilator is reset for any reason
Short self-test (SST)	An abbreviated version of EST to be run primarily by the operator. Makes detailed checks of the pneumatics and electronics. It also characterizes system leaks and system/tubing compliance to compensate during breath delivery. POST is run as part of SST.	Before patient is connected to the ventilator or after ventilator breathing circuit or humidifier is changed
Extended self-test (EST)	Lets a biomedical technician thoroughly test the operational integrity of the ventilator, both the electronics and pneumatics. POST and SST are part of EST.	• When the ventilator is serviced • As part of the ventilator performance verification
	NOTE: The performance verification, described in Section 5, is a more thorough test of the ventilator to verify specifications are met. The technician runs a partial or full performance verification after servicing the ventilator and at regular intervals.	
Ongoing background checks	These checks are performed so as not to disrupt normal operation. Includes these checks: reasonableness of analog inputs, power supply, dc voltages, pressure transducers, and more.	Automatically, continually, during ventilation and a smaller number in the standby mode

3.2 Power-on self-test (POST)

This subsection describes POST, including its operation, routines, and error handling.

3.2.1 Structure of POST

POST diagnoses electronic problems using a minimal amount of system hardware. It is composed of these three sections:

POST1 - Tests the breath delivery (BD) and user interface (UI) microcontrollers and associated circuitry. Each microcontroller runs its own version of POST1. Both versions are practically identical.

POST2 - Consists of tests that are specific to the BD and UI subsystems.

POST3 - Synchronizes both microcontrollers.

Each section of POST is in turn composed of various routines listed in Table 3-2. The tests within POST are generally ordered so that each one requires successively more operational hardware than the last, permitting electronic components to be systematically tested.

3.2.2 Running POST

To run POST, turn on the ventilator power switch. A message is displayed, indicating that POST is running, the ventilator software revision, and the hours of use remaining before preventive maintenance is required. At the end of POST (after approximately 8 seconds), the last valid settings are displayed. The appropriate indicator is lit to indicate the source of power to the ventilator.

During POST, the ventilator's safety valve is opened and the SAFETY VALVE OPEN light is turned on. The safety valve is closed when breath delivery begins.

3.2.3 How the ventilator responds to a POST error

If POST detects an error, it attempts to log the diagnostic code into the test log. In addition, it responds in one of these ways:

- **If the error could be expected to compromise proper ventilation**, a VENT INOP condition is declared. As a result, POST is terminated, and the ventilator is placed into the safety valve open (SVO) state. To clear the VENT INOP condition, you must repair the ventilator and run and pass EST before ventilation can resume. To do so, first cycle power to the ventilator. The ventilator will now let you access a limited set of service menu functions, such as reviewing the test log and running EST (see Section 4).
- **If POST detects (1) a low battery or no battery, (2) low oxygen supply pressure, (3) that a key was pressed while POST was being run due to a soft reset (rather than a power-on), (4) a blocked or missing air intake filter, (5) incorrect tubing connection between P_{cyl} and P_i/P_e transducer, or (6) the safety valve is stuck closed**, it notes the relevant condition, but POST otherwise continues. A technical alert is annunciated after the completion of POST to inform the operator.
- **If other types of errors are detected**, the error is logged and the ventilator resets. If POST still does not pass, the ventilator issues up to two more system resets, waiting for POST to pass, before a VENT INOP condition is declared. As a

result, POST is terminated and the ventilator is placed into the SVO state. To clear the VENT INOP condition, you must repair the ventilator and run and pass EST before ventilation can resume. To do so, first cycle power to the ventilator. The ventilator will now let you access a limited set of service menu functions, such as reviewing the test log and running EST (see Section 4).

- **If POST1 (UI) fails**, the message window displays this message:

  xxxx
  POST running...
  NPB 7x0 S/W Rev x
  PM Due: xxxxx

  where the first line is the diagnostic code.

- If POST1 (BD) or POST2 (BD) fails, the ventilator declares a VENT INOP condition. The ventilator flashes the diagnostic code on the BD section (left side) of the controller PCB in the following sequence:

1. The four LEDs flash the most significant digit (MSD) of the 5-digit error code.
2. All four LEDs flash on and off once.
3. The four LEDs flash the second MSD of the 5-digit error code.
4. All four LEDs flash on and off once.
5. The four LEDs flash the third MSD of the 5-digit error code.
6. All four LEDs flash on and off once.
7. The four LEDs flash the fourth MSD of the 5-digit error code.
8. All four LEDs flash on and off once.
9. The four LEDs flash the least significant digit (LSD) of the 5-digit error code.
10. All four LEDs flash on and off 10 times.

This sequence repeats indefinitely. Each digit is in binary format, with the most significant at the left.

For example, if the LEDs flash in this order (where X = LED on and O = LED off):

O O O O = 0

X O O X = 9

O O O X = 1

O O O O = 0

O X X O = 6

The diagnostic code is 09106. (See Section 6 for complete information on diagnostic codes.)

Table 3-2: POST routines

Section of POST	Description of routine
POST1 (UI and BD)	Microcontroller tests - Test registers and watchdog timers. Initializes microcontroller.
POST1 (UI and BD)	RAM tests
POST1 (UI and BD)	Segment and stack initialization - Initializes kernel memory segments and stacks.
POST1 (UI)	POST retries test - Determines whether POST has started, but failed to complete, three times.
POST1 (UI and BD)	Completion of microcontroller initialization
POST1 (UI and BD)	I/O initialization test - Checks digital I/O read registers to verify that digital I/O was properly initialized by hardware.
POST1 (UI and BD)	I/O initialization - Initializes digital outputs.
POST1 (UI and BD)	User interface initialization - Initializes all UI indicators.
POST1 (UI)	EPROM checksum test
POST1 (UI and BD)	Clock signal test - Verifies frequency of clock signal from other microcontroller.
POST1 (BD)	Motor controller chipset clock test - Verifies frequency of motor controller chipset clock.
POST1 (UI)	DUART test
POST1 (UI and BD)	POST1 completion
POST2 (BD)	Bus monitor test - Verifies that the microcontroller's bus monitor can detect bus error conditions.
POST2 (BD)	Start of piston test - Initializes and checks motor controller chipset, then starts piston movement test to check motor and optoswitches.
POST2 (BD)	Voltage tests - Checks +5 V controller PCB supply voltage and +1.2 V pressure solenoid PCB reference.
POST2 (BD)	BD serial EPROM read - Reads calibration and other transducer constants from serial EPROM on pressure solenoid PCB and writes them to RAM to facilitate later accessing.
POST2 (BD)	EPROM checksum test
POST2 (BD)	Completion of piston test
POST2 (UI)	Number of soft resets test - Checks whether three soft resets have occurred in the past 24 hours of operation.
POST2 (UI)	NVRAM test - Verifies integrity of NVRAM data.
POST2 (UI)	Hardware ID test - Verifies that versions of installed hardware are compatible with version of installed software.

Table 3-2: POST routines (continued)

Section of POST	Description of routine
POST2 (UI)	Voltages test - Checks voltages monitored by the UI.
POST2 (UI)	Temperatures test - Checks temperatures monitored by the UI.
POST2 (UI)	Real-time clock test - Verifies validity (not correctness) of real-time clock's date and time.
POST3 (UI and BD)	POST synchronization - Performs handshaking between UI and BD sections.
POST3 (UI and BD)	POST message exchange - The BD section sends the UI section this information: • BD POST status • Offsets for transducers zeroed by the BD section • Results of BD analog signal tests The UI section sends the BD section this information: • The ventilator model (*740* or *760*) in use • Current operating mode (for example, normal, SST, EST) • Offsets for transducers zeroed by the UI section • Overall status of UI POST • Algorithm constants • Constants stored in NVRAM
POST3 (BD)	Autozeroing of cylinder and exhalation pressure transducers
POST3 (UI)	Zeroing of exhalation flow sensor - Zeroes exhalation flow sensor. Updates the DAC values for the oxygen regulator pressure transducer and the inspiration pressure transducer using the DAC values stored in the serial EPROM the last time the transducers were zeroed.
POST3 (UI)	UI key release test - Is run only if a key was previously held down. Verifies that any key found down was released. If POST was run due to a soft reset, a failure of this test results in a technical alert. If POST was run due to an operator powering on the ventilator, the ventilator waits a maximum of 60 seconds for the operator to release the key. If the key is not released by then, a stuck-key failure is assumed.
POST3 (UI)	Batteries test - Check internal and external battery voltages to determine if the batteries are installed, and if installed, if they are adequately charged.

3.3 Short self-test (SST)

The short self-test (SST) is a subset of the extended self-test (EST), and is primarily for use by the operator. Consult the *Operator's Manual* for information on SST.

NOTE:

- Nellcor Puritan Bennett recommends that the SST be run every 15 days, between patients, and when the ventilator breathing circuit is changed. Nellcor Puritan Bennett recognizes that the protocol for running SST varies widely among healthcare institutions. It is not possible for Nellcor Puritan Bennett to specify or require specific practices that will meet all needs, or to be responsible for the effectiveness of those practices.
- If SST fails, the *700 Series Ventilator System* lets you keep rerunning SST. To more thoroughly troubleshoot a ventilator that has failed SST, cycle the unit's power while simultaneously holding down the MENU key. The ventilator declares a ventilator inoperative condition, enters a safety valve open state, and allows access to service menu functions. Use these functions to test and troubleshoot the ventilator, as described in Section 4.

3.4 Extended self-test (EST)

This subsection describes the extended self-test (EST), including its hardware requirements, operation, test routines, and error handling. You can run EST from the main or service menus.

NOTE:

Nellcor Puritan Bennett recommends that you always run the full EST before placing the ventilator into operation following service. For preliminary troubleshooting purposes, however, you may want to run EST tests individually by using the *EST tests* function under *Diagnostics/Service, Run tests* (see Section 4.2.3.2.1). The *EST tests* function does not write error information into NVRAM nor declare a VENT INOP condition when tests are failed.

3.4.1 When to run

Run EST before placing the ventilator into operation following service and as part of the ventilator's routine performance verification.

3.4.2 Hardware requirements (Table 3-3)

Table 3-3: Hardware requirements for EST

Description	Manufacturer or model or Nellcor Puritan Bennett part number
Ventilator breathing circuit	To use as test circuit: G-061208-00 or equivalent (adult, reusable, without heated wire) NOTE: To ensure that compliance compensation functions correctly, the user must run EST or SST with the circuit configured as intended for use on the patient.
Stopper, wye (no. 2)	G-061574-00 or local supplier
Stopper, inspiration port (no. 3)	G-061575-00 or local supplier
Oxygen source, 40 to 90 psi (275 to 620 kPa)	Local supplier

Warning

Due to excessive restriction of Air Liquide, Australian, and Dräger hose assemblies, reduced FIO_2 levels may result when oxygen inlet pressures < 50 psi (345 kPa) are employed. Make sure oxygen inlet pressure is approximately 50 psi (345 kPa) when using these hose assemblies, to maintain correct FIO_2 levels.

3.4.3 Running EST

Warning

- Before running EST, you must disconnect the ventilator from the patient. Running EST while the ventilator is connected to the patient can injure the patient.
- A fault identified in EST indicates that the ventilator or an associated component is defective. A defective ventilator or associated component should be repaired before the ventilator is returned to service, unless it can be determined with certainty that the defect cannot create a hazard for the patient, or add to the risks which may arise from other hazards.

Caution

To ensure accurate EST operation, run EST after the ventilator has been powered on for at least 10 minutes.

NOTE:

- During all testing, the pressure LED bar will display the expiratory pressure level. The current pressure is also displayed in the PRESSURE window in the PATIENT DATA section of the keyboard. These displays do not affect the testing but supply additional information when troubleshooting. The exception to this rule is during the piston leak test, when the pressure LED displays the cylinder pressure.
- When EST requires a user response, the ventilator will wait indefinitely.

1. Set up ventilator as for normal operation, complete with humidifier, if applicable, and leak-tight ventilator breathing circuit. You can run EST from the main menu or the service menu.
2. To run EST from the Main menu:
   a. Turn on the ventilator. If ventilation has already begun since the ventilator was turned on, turn off the ventilator and turn it back on without starting ventilation.
   b. Press MENU, turn the knob to select *Self test*, then press ACCEPT. Turn the knob to select *Extended self test*.

   To run EST from the service menu:
   a. Press MENU while simultaneously powering on ventilator. Do not release MENU until prompted by message window.
   b. After POST is completed, press MENU again, turn knob to select ***A. Service menu***, then press ACCEPT.
3. Turn knob to select ***EST***.
4. Respond to the following prompts:

Table 3-4: EST prompts

Message window display	Description
EST	Press ACCEPT to proceed.
Vent warming [*Time countdown*] CLEAR to bypass	This is displayed (followed by a countdown) if you just turned on the ventilator. When 10 minutes have passed since power on, the message is cleared and the ventilator displays the next prompt. NOTE: *It is important that the ventilator be on for 10 minutes before EST is run so that component temperatures can stabilize.* If the ventilator was recently running and is already warmed up, you can press CLEAR to override the **Vent warming** message and begin EST. Nellcor Puritan Bennett cannot guarantee the accuracy of test results in this case, however.
Is pt disconnected?	Confirm that patient is disconnected by pressing ACCEPT; or press CLEAR to return to service menu.
Block wye	Install no. 2 stopper and then press ACCEPT.

Table 3-4: EST prompts (continued)

Message window display	Description
POST running...	Wait a few seconds until POST is completed. NOTE: • If a single beep is not audible during POST, the main audible alarm may be malfunctioning. Troubleshoot as for EST main alarm test (Table 3-9). • During POST it is recommended that you not switch off ventilator power.
humidification device type Choose humidifier	Turn knob to select desired humidification device, then press ACCEPT. Device types include: **HME** (heat-and-moisture exchanger or “artificial nose”), **Dual heated wire** (humidifier with heated wires on both inspiratory and expiratory limbs), or **No heated wire** (humidifier without a heated wire on expiratory limb). Warning Incorrectly specifying the humidifier type during EST can affect the accuracy of spirometry calculations.
tubing type Choose tubing type	Turn knob to select either **Adult tubing** or **Pediatric tubing** and then press ACCEPT. Warning Incorrectly specifying the ventilator breathing circuit type during EST can cause an inappropriate sensitivity for the leak test and occlusion alarm. Nellcor Puritan Bennett recommends using pediatric circuits when ventilating patients with 5 mm or smaller internal-diameter artificial airways. NOTE: To ensure that compliance compensation functions correctly, the user must run EST with the circuit configured as intended for use on the patient.
ET size: x.x mm Choose ET size	Turn knob to select appropriate ET (endotracheal tube) size, and then press ACCEPT. Warning Specifying an ET tube size that is too large can cause premature termination of breaths on very small pediatric patients.

NOTE:

When EST requires a user response, the ventilator will wait indefinitely.

5. The ventilator automatically starts the first test in the sequence (Table 3-8). The tests all run automatically and consecutively, unless a fault occurs. Some tests display additional prompts requiring your response. EST prompts (informational prompts and those requiring your response) are listed in Table 3-6.

   At the end of each test, the test's name and pass/fail/fault status are displayed. If an EST test does not pass, you may still continue EST execution, although the entire EST will not pass until the error conditions are corrected.

NOTE:

It may be useful to complete EST even with errors, because information on multiple errors can facilitate troubleshooting.

Table 3-5: Key functions during EST

Key	Function
ACCEPT	Ignore failure and continue.
CLEAR	Repeat a test or return to prompt at start of a test.
Alarm reset	Retest from beginning of EST (when all tests are completed).
Alarm silence	Stop testing and skip to end of EST.
NOTE: The Alarm silence key is disabled under these conditions: (1) when EST is run as a result of a VENT INOP condition, and (2) (temporarily until the Circuit comp test is complete) if the tubing type or humidifier type you've selected has changed from the previous time EST was run.	
Manual insp	Use to override (when all tests are completed). Can only be used if EST has faulted or testing is incomplete.

Table 3-6: Prompts during EST testing

Prompt	Operator action
Disconnect O2 supply	Disconnect ventilator from oxygen supply. Press ACCEPT.
Reconnect O2 supply	Reconnect ventilator to oxygen supply. Press ACCEPT.
Disconnect I tubing	Disconnect tubing from inspiratory filter outlet. Leave inspiratory filter in place. Press ACCEPT.
I drop =*x x.x* at 100 *or* I drop =*x x.x* at 40 Reconnect I tubing	This is the inspiratory filter pressure drop in cmH_2O at a flow of 100 L/min (adult tubing) or 40 L/min (pediatric tubing). Reconnect tubing to inspiratory filter outlet. Press ACCEPT.
Unblock wye	Remove stopper from patient wye. Press ACCEPT.
Block wye	Insert a stopper into patient wye. Press ACCEPT.
Disconnect E tubing	Disconnect tubing from expiratory filter inlet. Leave expiratory filter in place. Press ACCEPT.
E drop = *x.x* at 100 *or* E drop =*x x.x* at 40 Reconnect E tubing	This is the expiratory filter pressure drop in cmH_2O at a flow of 100 L/min (adult tubing) or 40 L/min (pediatric tubing). Reconnect tubing to expiratory filter outlet. Press ACCEPT.
Block insp filt port	Remove inspiratory filter. Insert no. 3 stopper into inspiratory filter outlet. Press ACCEPT.
Reconnect I tubing	Remove stopper from inspiratory filter outlet. Reinstall inspiratory filter. Press ACCEPT.
Name of a section of display	Press ACCEPT to confirm that all LEDs/LCDs in named section are on.
Upper MDW = blocks?	Press ACCEPT to confirm that all pixels are turned on in upper half.
Lower MDW = blocks?	Press ACCEPT to confirm that all pixels are turned on in lower half.
Name of a key	Press named key.
High alarm sound	Confirm that you hear alarm by pressing ACCEPT.
Medium alarm sound	Confirm that you hear alarm by pressing ACCEPT.
No sound	Confirm that you *do not* hear alarm by pressing ACCEPT.
Is backup alarm ON?	Confirm that you hear alarm by pressing ACCEPT.

6. When the last test in the sequence is complete, the EST completion status is displayed (Table 3-7). Respond as indicated. Service the ventilator, then retest it. If certain tests do not pass, safe ventilation may be compromised, and the ventilator is rendered inoperative until it is repaired. This is called a ventilator *failure*. If certain other tests do not pass, but ventilation might not be compromised (subject to a trained operator's evaluation), this is called a ventilator *fault*. For each EST test, Table 3-8 shows whether its not passing would constitute a failure or fault.

NOTE:

Faults detected during EST may not require the ventilator to be serviced or removed from use immediately. A trained operator, however, must evaluate the situation and determine whether the ventilator can be used. *Failures* detected during EST require immediate servicing and removal of the ventilator from clinical use.

Table 3-7: EST completion status

If the EST result is:	It means:	Do this:
EST passed	All tests were performed and all passed.	**To retest from start of test sequence**, press alarm reset key. **To exit EST and resume ventilation**, press ACCEPT. Unblock the wye as directed, then press ACCEPT. POST now runs, and ventilation resumes at last valid settings.
EST incomplete	All tests passed, but some tests were skipped. The skipped tests were passed on a previous run.	**To retest from the start of the test sequence**, press the alarm reset key. **To exit EST and resume ventilation**, press MANUAL INSP. You are then asked whether you want to use the override feature. Press MANUAL INSP again to complete the override. Unblock the wye as directed, then press ACCEPT. POST now runs, and ventilation resumes at last valid settings.

Table 3-7: EST completion status (continued)

EST fault	One or more tests did not pass. These tests might not compromise the ventilator's ability to ventilate safely, based on the operator's evaluation of the situation.	**To retest from the start of the test sequence**, press the alarm reset key. **To exit EST and resume ventilation**, press MANUAL INSP. You are asked whether you want to use the override feature. Press MANUAL INSP again to complete the override. Unblock the wye as directed, then press ACCEPT. POST now runs, and ventilation resumes at last valid settings.
	Warning Do not use a ventilator that has completed EST with a fault status without verifying its operational integrity by means other than EST and determining that the patient will not be placed at risk.	
EST failed	One or more tests failed that might compromise the ventilator's ability to ventilate safely. A VENT INOP condition is declared when you cycle power to the ventilator.	Repair and retest the ventilator. **To retest from the start of the test sequence**, press the alarm reset key.

Table 3-8: EST tests

No.	Test	Purpose	Status	In SST?	Comments
1	DAC-ADC loop test	A loopback test to check D/A and A/D converters' operation	Failure if not passed	No	
2	Safety valve test	Verifies that safety valve relieves excess circuit pressure	Failure if not passed	Yes	
3	Motor sensor test	Checks operation of rotary encoder	Failure if not passed NOTE: To ensure that compliance compensation functions correctly, the user must run EST or SST with the circuit configured as intended for use on the patient.	No	

Table 3-8: EST tests (continued)

No.	Test	Purpose	Status	In SST?	Comments
4	Zeroing of Po	Zeroes oxygen regulator pressure transducer	Fault if not passed	No	Disconnect and reconnect oxygen supply, as directed. Press ACCEPT to signify you have performed each requested action.
	NOTE: Overriding this fault could result in inaccurate oxygen percentage delivery.				
5	O2 solenoids test	Checks oxygen solenoids and oxygen sensor	Fault if not passed	No	
	NOTE: Overriding this fault could result in inaccurate oxygen percentage delivery.				
6	Flow sensor test	Checks accuracy of exhalation flow sensor	Failure if not passed	Yes, but not identical	
7	Leak test	Checks ventilator breathing circuit for leaks	Fault if not passed	Yes	
	NOTE: Overriding this fault could cause improper compliance compensation, inaccurate tidal volume delivery, or autocycling.				
	P_e P_{cyl} compare (part of test 7)	Verifies proper functioning of pressure transducers and ventilator breathing circuit	Fault if not passed	Yes	
	NOTE: Overriding this fault could cause improper compliance compensation, inaccurate tidal volume delivery, or autocycling.				
	Auto zero sol test (part of test 7)	Verifies if P_e P_{cyl} auto zero solenoids can be engerized and de-energized.	Failure if not passed	Yes	

Table 3-8: EST tests (continued)

No.	Test	Purpose	Status	In SST?	Comments
8	Circuit comp test	Determines ventilator breathing circuit compliance	Fault if not passed	Yes	
	NOTE: Overriding this fault could cause improper compliance compensation, inaccurate tidal volume delivery, or autocycling.				
9	I/E filter test	Checks pressure drop across inspiratory and expiratory limbs of entire patient system. Checks pressure drop across filters.	Fault if not passed	Yes	Mandatory in EST, but optional in SST. Disconnect and reconnect inspiration (I) tube from/to inspiratory filter outlet, and exhalation (E) tube from/to expiratory filter inlet, as directed. Block and unblock wye with a no. 2 stopper, as directed. Press ACCEPT to signify you have performed each requested action.
	NOTE: Overriding this fault could result in inadequate bacteria protection or excessive resistance to inspiration or exhalation.				
10	PEEP system test	Verifies that PEEP system can generate and maintain preset PEEP levels	Failure if not passed	Yes, but not identical	Verifies that PEEP system can generate and maintain preset PEEP levels within either of two sets of limits. If results are within the inner set of limits, test passes the first time. If the results are outside of the outer set of limits, test fails the first time. If the results are outside the inner limits but within the outer limits, the ventilator adjusts its calibration table in nonvolatile RAM (NVRAM) and repeats the test to verify the calibration. The test fails if the calibration cannot be verified after five attempts.
11	Check valve test	Checks check valve outlet port of cylinder	Failure if not passed	No	

Table 3-8: EST tests (continued)

No.	Test	Purpose	Status	In SST?	Comments
12	Piston leak test	Checks piston leak against a table of leak values stored in NVRAM	Failure if not passed	No	First remove inspiratory filter; then block and unblock inspiratory filter port as directed, using no. 3 stopper. Press ACCEPT to signify you have performed each requested action. Replace inspiratory filter at end of test.
13	Lights-displays test	Verifies that lights and displays function	Failure if not passed	No	Observe each named display, and press ACCEPT to verify that it is lit. Press CLEAR if a display is not lit.
14	Keys test	Verifies that every row and column of key matrix can be correctly read	Failure if not passed	No	Press each named key (each key's LED will also be lit). Press CLEAR if a key's LED is not lit.
15	Main alarm test	Checks whether various alarm sounds are audible (at maximum volume)	Failure if not passed	Yes	Listen for each named sound, then press ACCEPT to verify that it is audible. Press CLEAR if a sound is not audible.
16	Backup alarm test	Checks operation of backup alarm circuit	Fault if not passed	Yes	Press ACCEPT if alarm is audible or press CLEAR if alarm is not audible.
	NOTE: Overriding this fault could result in no audible alarm if the main speaker fails.				
17	Fan test	Verifies that main fan is operating correctly by reading fan status bits	Failure if not passed	No	
18	Heaters test	Verifies correct operation of heaters in exhalation system	Fault if not passed	Yes	
	NOTE: Overriding this fault could result in inaccurate monitoring of exhaled volume or damage to the ventilator's flow sensor or exhalation valve.				

3.4.4 Troubleshooting

Refer to Table 3-9 for EST troubleshooting information, including a description of how the ventilator performs each test. These procedures are sequenced to correct the most probable malfunction or to present the most efficient corrective action first. The proposed fixes listed, however, may not always correct the particular problem.

NOTE:

It is recommended that you use the *Sensor data* function (Section 4.2.1) to help confirm the failure of suspect components.

Table 3-9: EST troubleshooting

EST test no.	Test name	How the ventilator performs the test	Corrective action
1	DAC-ADC loop test	Zeroes flow sensor pressure transducer (P_f) and exhalation pressure transducer (P_e). Compares transducer readings (from A/D converter) to expected (autozero DAC) values.	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
2	Safety valve test	Pressurizes system, incrementing by 0.4 cmH_2O every 10 ms, to a maximum of 70 cmH_2O, until safety valve cracks. Compares expected pressure with actual cracking pressure.	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
3	Motor sensor test	Moves piston at 50, 100, and 150 L/min and compares monitored velocities against expected values.	1. Check harness from controller PCB to motor/encoder. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace pressure solenoid PCB.
4	Zeroing of Po	Zeroes oxygen pressure transducer in oxygen regulator and reads pressure. Compares pressure reading with calibration value in NVRAM.	1. Make sure oxygen source pressure is between 40 and 90 psi (275 and 620 kPa). 2. Repeat this test and verify that oxygen is disconnected and reconnected when prompted. 3. Check that oxygen regulator pressure transducer/ventilator head harness connection is secure. 4. Recalibrate oxygen regulator pressure transducer. 5. Replace oxygen regulator pressure transducer. 6. Replace pressure solenoid PCB.

Table 3-9: EST troubleshooting (continued)

EST test no.	Test name	How the ventilator performs the test	Corrective action
5	O2 solenoids test	Verifies that O_2 is within 21% ±3% before energizing. Energizes low-flow and high-flow solenoids individually and waits for significant change in FIO_2. Verifies that oxygen sensor reads >25% O_2 (low-flow solenoid) and >50% O_2 (high-flow solenoid).	1. Make sure oxygen source pressure is between 40 and 90 psi (275 and 620 kPa). 2. Check that oxygen regulator assembly/ventilator head harness connection is secure. 3. Use *Review constants* function in service menu to verify that oxygen regulator assembly constants are as stated on calibration label. Input correct constants, as required. 4. Check oxygen solenoid resistances (low-flow--95 to 126 Ω, high-flow--36 to 51 Ω). Replace oxygen regulator assembly, as required. 5. Verify that voltage to solenoids is between +23 to +25 V. 6. Replace oxygen regulator assembly. 7. Replace pressure solenoid PCB.
6	Flow sensor test	Autozeroes flow sensor. Delivers set rate (20, 100, and 150 L/min for adult tubing or 10, 40, and 80 L/min for pediatric tubing). Verifies that exhaled volumes are within ±10% of delivered volumes.	1. Make sure room temperature is not too low. Make sure ventilator has warmed up. 2. Make sure oxygen source pressure is between 40 and 90 psi (275 and 620 kPa). 3. Using *Sensor data* function in service menu, verify that flow sensor transducer temperature (Txdcr) is between 45 and 55°C. Verify correct tubing connections to flow sensor. 4. Use *Review constants* function in service menu to verify that flow sensor constant is as stated on calibration label. Input correct constant, as required.

Table 3-9: EST troubleshooting (continued)

EST test no.	Test name	How the ventilator performs the test	Corrective action
7	Leak test	Pressurizes system to 50 cmH_2O. Ensures that pressure has not dropped below 40 cmH_2O. Monitors exhalation pressure over 6-second period. Verifies that leak is <7 cmH_2O (adult circuit) or <9.5 cmH_2O (pediatric circuit).	1. Verify that tubing setup is correct, that all tubing connections and wye block are secure, and that tubing has no apparent leaks. 2. Verify that inspiratory and expiratory filters are properly installed. 3. Verify that safety valve is closed during this test. 4. Verify that pressure sensing tubes are not leaking. 5. Replace exhalation valve. 6. Replace elbow tube (between inspiration manifold and ventilator outlet). 7. Replace cylinder outlet check valve.
	P_e P_{cyl} compare	Reads cylinder and exhalation pressure transducers. Verifies that readings are within 3.5 cmH_2O of each other.	1. Verify that tubing connections between exhalation and cylinder pressure transducers and their pressure taps are secure. 2. Perform P_eP_{cyl} gain equalization. NOTE: Do not perform the P_e P_{cyl} gain equalization unless the leak test has passed.
	Auto zero solenoid test	During pressurization, turns on the P_{cyl} solenoid ($P_{cyl}1$) and reads the pressure (0 cmH_2O). If the pressure is greater than 6 cmH_2O, the test fails. It turns the solenoid off and reads the pressure again (P_{cyl} 2). The absolute difference between P1 and P2 should be no greater than 20 cmH_2O or the test fails. The P_e test is identical to the one above, except it is perfomed after pressurization and during leak measurement.	1. Verify that the tubing connections between exhalation and cylinder pressure transducers and their pressure taps are secure. 2. Replace autozero valve. 3. Replace pressure solenoid PCB if steps 1 and 2 do not resolve the problem.

Table 3-9: EST troubleshooting (continued)

EST test no.	Test name	How the ventilator performs the test	Corrective action
8	Circuit comp test	Pressurizes system to 10, 40, and 70 cmH_2O (flow of 10 L/min). Measures exhalation pressure, cylinder pressure, and piston position for each pressure, and averages each value at all three positions. Verifies that compliance is between 1 and 12 mL/cmH_2O (adult circuits) or between 1 and 8 cmH_2O (pediatric circuits). If test fault is overridden, compliance defaults to 2.5 mL/cmH_2O (adult circuit) or 1.5 mL/cmH_2O (pediatric circuit).	1. Verify that leak test (test 7) has passed. 2. Verify that tubing setup is correct, that all tubing connections and wye block are secure, and that tubing has no apparent leaks. 3. Verify that both inspiratory and expiratory filters are properly installed. 4. Verify that safety valve is closed during this test.
9	I/E filter test	Establishes flow of 100 L/min (adult circuits) or 40 L/min (pediatric circuits). Makes four separate pressure measurements with limbs disconnected/connected, to determine pressure drops. Verifies that total pressure drop across each limb, including filter, is ≤ 5 cmH_2O (adult circuits) or ≤ 3 cmH_2O. Considers an occlusion to have occurred if pressure drop exceeds 80 cmH_2O during test.	1. Make sure operator correctly performed required actions. 2. Replace inspiratory filter. 3. Replace expiratory filter. 4. Check for an occlusion in inspiratory or expiratory limb.
10	PEEP system test	Commands PEEP pump to deliver 5, 10, 15, 20, 25, 30, and 35 cmH_2O. Measures resulting PEEP pressures and verifies that all are within range. Updates calibration table in NVRAM as required (provided measured pressures are in range) and then reruns PEEP system test to verify calibration.	1. Verify that leak test (test 7) has passed. 2. Verify that tubing setup is correct, that all tubing connections and wye block are secure, and that tubing has no apparent leaks. 3. Rerun the test and check that the PEEP pump gradually increases its displacement as the test proceeds. 4. Verify that voltage to PEEP pump is between +23 and +25 V. 5. Recalibrate PEEP pump. 6. Verify that exhalation solenoid tubing connections are secure. 7. Check exhalation solenoid resistance (95 to 126 Ω). Replace solenoid, as required. 8. Replace PEEP pump inlet filter. 9. Replace PEEP pump.

Table 3-9: EST troubleshooting (continued)

EST test no.	Test name	How the ventilator performs the test	Corrective action
11	Check valve test	Establishes flows of 50, 100, and 150 L/min while monitoring cylinder and inspiration pressure transducer readings. Verifies that difference between these two, simultaneous transducer readings < 4 cmH_2O.	Replace cylinder outlet check valve. NOTE: If the monitored oxygen concentration of delivered gas is too low, the outlet or inlet check valve may be stuck open. Apply negative pressure to the wye. If system pressure stays low, check for a stuck check valve.
12	Piston leak test	Advances piston to maintain cylinder pressure of 40 cmH_2O. Verifies that at each calibration position, piston leak is within range of calibrated leak values in NVRAM.	1. Make sure oxygen source pressure is between 40 and 90 psi (275 and 620 kPa). 2. Verify that ventilator outlet port is blocked and not leaking. 3. Perform a leak test using diagnostic EST (*Diagnostics/Calib* function in service menu). 4. Use *Review constants* function in service menu to verify that piston leak constants are as stated on calibration label. Input correct constants, as required. 5. Replace cylinder inlet check valve.
13	Lights-displays test VENTILATOR STATUS indicators VENTILATOR SETTINGS LEDs VENTILATOR SETTING LCDs PATIENT DATA LEDs PATIENT DATA LCDs Message window (LCD panel) upper and lower blocks	Turns on lights and displays and verifies that user reports them lit.	1. Verify that LCD panel/UI display PCB connection is secure. 2. Replace LCD panel. 3. Replace UI display PCB. 4. Replace controller PCB.
14	Keys test	Prompts user to press keys and checks for keyswitch closure.	1. Replace keyboard assembly. 2. Replace controller PCB.
15	Main alarm test	Sounds alarm at three volumes and verifies that user reports hearing it.	1. Check speaker resistance (6 to 8 Ω). 2. Check main ventilator head harness continuity. Replace harness, as required. 3. Replace speaker. 4. Replace pressure solenoid PCB.

Table 3-9: EST troubleshooting (continued)

EST test no.	Test name	How the ventilator performs the test	Corrective action
16	Backup alarm test	Sounds piezo alarm and verifies that user reports hearing it.	1. Check main ventilator head harness continuity. Replace harness, as required. 2. Replace speaker. 3. Replace pressure solenoid PCB.
17	Fan test	Checks air flow thermistor reading to determine whether fan is operational.	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and attained a steady-state temperature. 2. Verify that main fan rotates. 3. Check that main fan/ventilator head harness connection is secure. 4. Check that main fan filter is present and clean. Clean or replace as required. 5. Check that air flow thermistor assembly/ ventilator head harness connection is secure. 6. Verify that voltage to fan is between +23 and +25 V. If voltage is present and within range, replace fan. It it is not present or is out of range, replace pressure solenoid PCB.
18	Heaters test	Checks thermistor assembly readings to determine whether heaters are operational.	1. Verify that control thermistor (top) is correctly installed. 2. Verify that heater and thermistor assemblies are securely connected to main ventilator head harness. 3. Replace exhalation heater assembly. 4. Replace exhalation thermistor assembly. 5. Replace pressure solenoid PCB.

3.5 Ongoing checks

Ongoing runtime checks are continually performed during ventilation. If an unexpected condition is detected, a code is logged into the alert log. In addition, the ventilator responds in one of the following ways depending on the type of condition detected. To troubleshoot the ventilator, review the alert log (Section 4.2.4). The diagnostic codes stored in the log are further described in Section 6.

- **Technical alert -** The ventilator has detected an undesirable condition arising from a current or pending malfunction of the ventilator or its supply gas. Examples are battery not charging or ventilator internal temperature too high. The code is logged into the alert log. Ventilation continues, although the ventilator displays a message describing the condition; see Section 7 for a listing of these messages. The audible alarm is sounded and the ALARM or CAUTION light is lit. Some technical alerts are automatically reset if the triggering condition disappears.
- **Software error or hardware error not expected to compromise ventilation -** The ventilator has detected an error while running an ongoing check. The ventilator is reset. The code is logged into the alert log. If more than three such errors are detected within 24 hours, a VENT INOP condition is declared, which results in the ventilator being placed in the SVO state. To clear the VENT INOP condition, you must repair the ventilator and run and pass EST before ventilation can resume. To do so, first cycle power to the ventilator. The ventilator will now let you access a limited set of service menu functions only (see Section 4). Use the *EST* function to run the extended self-test. The results of the EST run, the contents of the test and/or alert log, and other service menu functions will help you determine what to repair. If the error recurs or if multiple errors occur, the problem requires corrective action. Contact your regional Nellcor Puritan Bennett Technical Support.
- **Hardware error that might compromise ventilation -** A VENT INOP condition is declared, which results in the ventilator being placed in the SVO state. The code is logged into the alert log. To clear the VENT INOP condition, you must repair the ventilator and run and pass EST before ventilation can resume, as described above.

Service and utility functions

Warning

Never perform the service or utility functions while a patient is connected to the ventilator. The ventilator does not provide normal ventilatory support during these functions.

4.1 Introduction

This section describes the *700 Series Ventilator System*'s service and utilities functions, including prompts and expected responses.

4.1.1 Accessing the service or utilities functions

NOTE:

When you cycle power to a ventilator with an active VENT INOP condition, you are given automatic access to a limited set of service menu functions. You must repair the ventilator and run and pass EST before ventilation can resume. Use the *EST* function plus the other service menu functions to test, troubleshoot, and repair the unit.

Access the service or utilities functions as follows:

1. Press the MENU key while simultaneously powering on the ventilator. Do not release the MENU key until prompted by the message window.
2. Press the MENU key again; then turn the knob to locate either **A. Service menu** or **B. Utilities**. Press ACCEPT to select the desired menu.

4.1.2 Summary of functions

Table 4-1 and Table 4-2 summarize the ventilator's *Service* and *Utilities* functions.

Table 4-1: Service functions

Description	Purpose
Sensor data	Primarily for factory use. During ventilation displays monitored parameters, including pressures, temperatures, voltages, battery current, PEEP motor on-time, delivered volume, flow BTPS, and oxygen percentage.
EST	Runs extended self-test (see Section 3 for details on EST).
Diagnostics/Calib	Enables the serial port and up/download (if the Communications option is installed, you can configure serial ports A and B), runs individual EST tests, performs calibrations, erases the contents of the test and alert logs, resets service data, and lets you review and manually update calibration constants.
Review alert log	Lets you read the alert log contents
Test data	Lets you read the test log contents and the EST test results

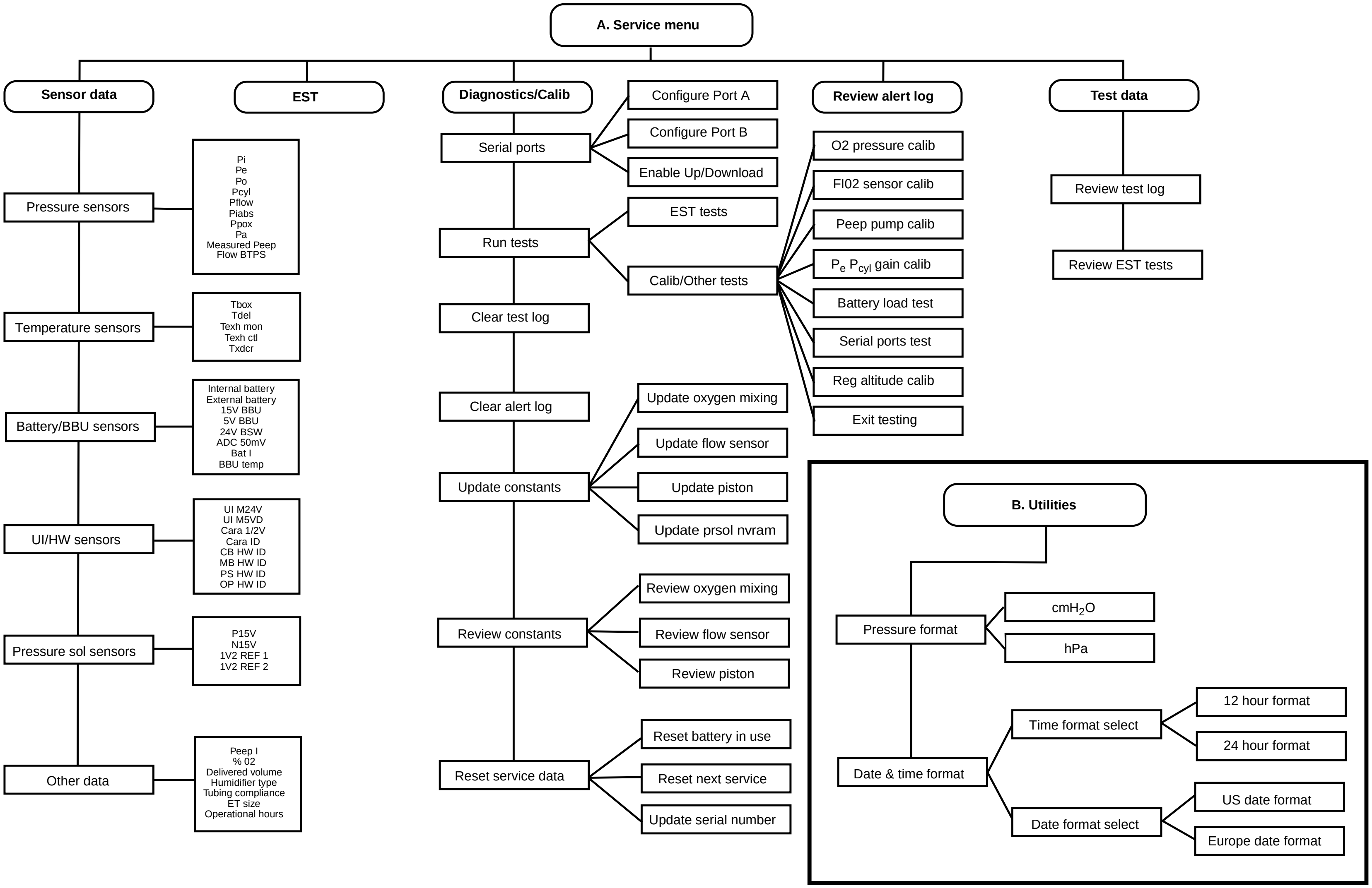
Table 4-2: Utilities menu functions

Description	Purpose
Pressure format	Lets you choose the unit for display of pressures (cmH_2O or hPa).
Date & time format	Lets you choose the format for display of date (European--with day first, followed by month, or US--with month first, followed by day) and time (12- or 24-hour clock).

4.1.3 Navigating the *Service* and *Utilities* menus

Figure 4-1 shows you how to navigate through all the *Service* and *Utilities* menu functions. In general, the ventilator controls serve these functions:

- The knob lets you locate a function or menu.
- The ACCEPT key selects the function or allows you to proceed to the function's next prompt.
- The CLEAR key returns you to the start of the function or to the previous menu.


A. Service menu
Sensor data
EST
Diagnostics/Calib
Review alert log
Test data
Pressure sensors
Pi
Pe
Po
Pcyl
Pflow
Piabs
Ppox
Pa
Measured Peep
Flow BTPS
Temperature sensors
Tbox
Tdel
Texh mon
Texh ctl
Txdcr
Battery/BBU sensors
Internal battery
External battery
15V BBU
5V BBU
24V BSW
ADC 50mV
Bat I
BBU temp
UI/HW sensors
UI M24V
UI M5VD
Cara 1/2V
Cara ID
CB HW ID
MB HW ID
PS HW ID
OP HW ID
Pressure sol sensors
P15V
N15V
1V2 REF 1
1V2 REF 2
Other data
Peep I
% 02
Delivered volume
Humidifier type
Tubing compliance
ET size
Operational hours
Serial ports
Configure Port A
Configure Port B
Enable Up/Download
Run tests
EST tests
Calib/Other tests
O2 pressure calib
FI02 sensor calib
Peep pump calib
P_e P_{cyl} gain calib
Battery load test
Serial ports test
Reg altitude calib
Exit testing
Clear test log
Clear alert log
Update constants
Update oxygen mixing
Update flow sensor
Update piston
Update prsol nvram
Review constants
Review oxygen mixing
Review flow sensor
Review piston
Reset service data
Reset battery in use
Reset next service
Update serial number
Review test log
Review EST tests
B. Utilities
Pressure format
cmH_2O
hPa
Date & time format
Time format select
12 hour format
24 hour format
Date format select
US date format
Europe date format

7-00318

Figure 4-1. Navigating the *Service* and *Utilities* menus

4.1.4 About the test and alert logs and EST test results

The results of ventilator self-tests are stored in NVRAM, as follows:

- Two logs store diagnostic codes corresponding to unexpected conditions detected by the ventilator. Conditions detected during POST, SST, EST, and calibrations (but not the pass/fail status of EST tests) are stored in the *test log*. Technical alerts and other conditions detected during the ventilator's ongoing checks are stored in the *alert log*. Each log holds up to ten codes, corresponding to the ten most recently detected conditions. If the same condition is detected more than once in succession, that code is logged only once, but the number of occurrences is incremented and the time stamp is updated.
- EST test results are stored in NVRAM separately from the test logs. The pass/fail status of the most recent execution of each EST test is stored.

NOTE:

The EST test results stored in NVRAM are always the results from running a full EST. EST tests run individually for diagnostic purposes (**Run tests** under **Diagnostics/Calib**) are not retained in NVRAM.

4.2 Service functions

4.2.1 Sensor data

This function lets you view parameters that are monitored by the ventilator, such as pressures, temperatures, voltages, battery current, PEEP pump current, delivered volumes, flows (BTPS), and oxygen percentage, among others. Sensor data can be viewed at any time while the *Service menu* is active, including while the unit is ventilating; it is the only service function that can be used during ventilation.

To access the *Sensor data* functions from the **A. Service menu** prompt, turn the knob until **Sensor data** is displayed, then press ACCEPT. Now turn the knob to display the desired parameter group. The parameter groups are:

- Pressure sensors
- Temperature sensors
- Battery/BBU sensors
- UI/HW sensors
- Pressure sol sensors
- Other data

When you have selected a parameter group, you will see the following display:

Message window display	Description
name of parameter group (for example, Other data*)*	Turn the knob to locate the desired parameter group; then press ACCEPT.
specific parameter (for example: % O2*)*	Turn the knob to locate the specific parameter desired; then press ACCEPT to view the specific parameter reading (Table 4-3 through Table 4-8). Use the acceptable ranges provided as guidelines in interpreting the readings.
specific parameter sensor reading (for example: % O2 60%)	The current reading is updated every 1 second and whenever you press ACCEPT. NOTE: For analog measurements that are converted to digital, the number of A/D converter counts may also be listed in parentheses after the measurement.

Table 4-3: Pressure sensors

Specific parameter	Description	Should read within this range...
Pi*	Inspiration pressure (in cmH_2O)	-40 to 120 cmH_2O
Pe*	Exhalation pressure (in cmH_2O)	-40 to 120 cmH_2O
Po	Oxygen regulator pressure (in cmH_2O)	0 to 2672 cmH_2O
Pcyl*	Cylinder pressure (in cmH_2O)	-40 to 125 cmH_2O
Pflow*	Exhalation flow (in L/min)	-0.5 to 3.5 cmH_2O (each cmH_2O is approximately 135 L/min STPD)
Piabs*	Inspiration pressure transducer (absolute reading) (in cmH_2O)	485 to 1225 cmH_2O
Ppox	Oxygen sensor reading as a partial pressure (in cmH_2O)	Pa x FIO_2 (as a fraction, in cmH_2O)
Pa	Atmospheric pressure (in cmH_2O)	475 to 1155 cmH_2O
Measured Peep*	PEEP measurement (in cmH_2O)	Patient setting ±(0.6 + 10%)
Flow BTPS*	Exhalation flow (BTPS) (in L/min)	Depends on patient's exhaled flow
*Varies with patient settings during ventilation.		

Table 4-4: Temperature sensors

Specific parameter	Description	Should read within this range...
Tbox	Ventilator internal temperature measured on pressure solenoid PCB (in ^{o}C)	5 to 70°C
Tdel	Inspiration manifold thermistor reading (in ^{o}C)	5 to 70°C
Texh mon	Exhalation system monitor temperature (in ^{o}C)	Depends on temperature of delivered gas
Texh ctl	Exhalation system control temperature (in ^{o}C)	42 to 75°C (controlled at 50°C nominally)
Txdcr	Temperature at flow sensor transducer (on pressure solenoid PCB) (in ^{o}C)	40 to 70°C (controlled at 50°C nominally)

Table 4-5: Battery/BBU sensors

Specific parameter	Description	Should read within this range...
Internal battery	Internal battery voltage reading, taken with charger off (in V)	18 to 30 V. Internal battery reading only available when ventilator is powered by internal battery (otherwise reading is **N/A**).
External battery	External battery voltage reading, taken with charger off (in V)	18 to 30 V (if connected). External battery reading only available when ventilator is powered by external battery (otherwise reading is **N/A**).
15V BBU	Voltage of +15 V line on BBU PCB (in V)	14.2 to 15.8 V
5V BBU	Voltage of +5 V line on BBU PCB (in V)	4.9 to 5.1 V
24V BSW	Input to BBU PCB from power supply (in V)	22.5 to 25.5 V
ADC 50mV	Unused	
Bat I	Battery current (in A)	Charging: 2 A typical (positive reading) Charged: < 0.6 A Battery in use: negative reading
BBU temp	Temperature measured on BBU PCB (in ^{o}C)	5 to 70 ^{o}C

Table 4-6: UI/HW sensors

Specific parameter	Description	Should read within this range...
UI M24V	+24 V on UI PCB (in V)	19.5 to 30.7 V
UI M5VD	+5 V on UI PCB (in V)	4.7 to 5.4 V
Cara 1/2 V	Ventilator model	740: approx. 0 760: 1023 counts
Cara ID	Unused.	
CB HW ID	Controller PCB hardware revision	Depends on PCB revision
MB HW ID	BBU PCB hardware revision	Depends on PCB revision
PS HW ID	Pressure solenoid PCB hardware revision	Depends on PCB revision
OP HW ID	Reserved for future use	For future use

Table 4-7: Pressure sol sensors

Specific parameter	Description	Should read within this range...
P15V	+15 V measured on pressure solenoid PCB (in V)	14.0 to 15.9 V
N15V	-15 V measured on pressure solenoid PCB (in V)	13.7 to 15.7 V
1V2 REF 1	+1.2 V reference 1 on pressure solenoid PCB (in V)	1.2 to 1.3 V
1V2 REF 2	+1.2 V reference 2 on pressure solenoid PCB (in V)	1.2 to 1.3 V

Table 4-8: Other data

Specific parameter	Description	Should read within this range...
Peep I*	PEEP pump current (in counts)	183 to 818 counts
% O2*	Monitored oxygen percentage	9 to 109%
Delivered volume*	Delivered volume (in mL/min)	40 to 2000 mL
Humidifier type	As specified during SST/EST	HME, Dual heated wire, No heated wire
Tubing compliance	Ventilator breathing circuit compliance determined during the last run of SST/EST (in mL/cmH_2O)	Pediatric or Adult
ET size	As specified during SST/EST	3 to 9 mm
Operational hours	Total hours ventilator has operated	
*Varies with patient settings during ventilation. Can also be read when not ventilating.		

4.2.2 EST (Extended self-test)

This function lets you run the full EST. To access EST from the **A. Service menu** prompt, turn the knob until **EST** is displayed, then press ACCEPT. (You can also access EST from the main menu.)

For a detailed discussion of ventilator testing, refer to Section 3.

4.2.3 Diagnostics/Calib

NOTE:

All service functions can be accessed while the ventilator is not ventilating. When ventilating, the only function accessible is the *sensor data* function.

This function lets you:

- Configure serial ports A and B (if the Communicatons option is installed), and enable up/download.
- Run individual EST tests
- Calibrate the oxygen regulator pressure transducer, oxygen sensor, PEEP pump, equalize the gain of the exhalation pressure transducer/cylinder pressure transducer (P_e/P_{cyl}), run the battery load test, run the serial ports test, and adjust the oxygen regulator for use at high or changing altitudes.
- Exit service mode
- Erase the contents of the test log
- Erase the contents of the alert log
- Manually input calibration constants into NVRAM for the oxygen regulator assembly, the flow sensor, the piston/cylinder assembly, and the pressure solenoid PCB.
- Review calibration constants in NVRAM
- Reset hours of preventive maintenance, battery use, and update serial number.

To access the *Diagnostics/Calib* functions from the **A. Service menu** prompt, turn the knob until **Diagnostics/Calib** is displayed, then press ACCEPT. Then turn the knob to locate the desired *Diagnostics/Calib* function.

Table 4-9 tells you when to perform calibrations or update NVRAM constants.

Table 4-9: Performing calibrations/Updating NVRAM Constants

When this occurs	Do the following
Oxygen sensor replaced	Perform *FIO2 sensor calib* function.
Oxygen regulator pressure transducer replaced	Perform *O2 pressure calib* function.
PEEP pump replaced	Perform *PEEP pump calib* function.
Oxygen solenoid assembly replaced	Perform *Update constants* function.
Flow sensor replaced	Perform *Update constants* function.
Piston/cylinder assembly replaced	Perform *Update constants* function.
Pressure solenoid PCB replaced	Perform *Update prsol nvram*, *FIO2 sensor calib,* and *O2 pressure calib* functions. **Caution** To ensure correct function of the pressure solenoid PCB, be sure to perform the *Update prsol nvram* function *before* the *FIO2 sensor calib* and *O2 pressure calib* functions.
P_e P_{cyl} compare test in EST fails	Perform *Pe Pcyl gain calib* function.

4.2.3.1 Enable serial port

This function lets you enable the serial port to transfer data between the ventilator and a computer. The serial port will remain enabled until the ventilator is powered off. If the ventilator has a communications port, you can either enable the serial port or configure it.

Message window display	Description
Serial ports	Press ACCEPT to proceed.
Configure port A or Configure port B	Press ACCEPT to proceed. Turn knob to change values of B (baud), D (databits), or P (parity) and press ACCEPT to proceed. These settings do not affect the serial port on the controller PCB, whose configuration is set at 19200 Baud, 8 data bits, and no parity.
Enable up/download	Press ACCEPT to enable. Once up/downloading is enabled, you can use one serial port to transfer service data: • serial port A only, if the Communications option is installed. • only the serial port on the controller PCB, if the Communications option is *not* installed. When up/downloading is enabled, normal operation of the Communications panel ports is disabled. The up/downloading function is disabled once ventilator settings are accepted or you turn the ventilator power switch off and back on again.

Settings for some serial devices include:

- Nellcor Puritan Bennett CliniVision *HandHeld* and *VentNet* systems: 9600 Baud, 8 data bits, odd parity.
- Hewlett-Packard Merlin patient monitor: 9600 Baud, 7 data bits, even parity.
- SpaceLabs patient monitor: 9600 Baud, 8 data bits, odd parity.

NOTE:

Settings and other specifications for external devices are subject to change. Consult the external device manufacturer for the most current setting information.

4.2.3.2 Run tests

This function lets you run individual EST tests, perform ventilator calibrations, and other tests. To access *Run tests* functions from the **Diagnostics/Calib** prompt, turn the knob until **Run tests** is displayed, then press ACCEPT. Then turn the knob to locate the desired *Run tests* function.

4.2.3.2.1 EST tests: Running individual EST tests (diagnostic EST)

This function lets you run EST tests individually. It operates almost identically to EST, except that:

- Test results are not written to NVRAM, and
- A test failure does not cause a VENT INOP condition to be declared. Thus, a ventilator that fails an EST test can continue to operate *for troubleshooting purposes only.*
- Pressing ALARM RESET while running diagnostic EST returns you to the start of the full (non-diagnostic) EST.

NOTE:

- Nellcor Puritan Bennett recommends that you always run the full EST before placing the ventilator into operation following service. For preliminary troubleshooting purposes, however, you may want to run EST tests individually. The *EST tests* function does not write error information into NVRAM nor declare a VENT INOP condition when tests are failed.
- This *EST tests* function does *not* substitute for the full EST. After a ventilator is serviced, it must be tested using the full EST before being returned to service.

Message window display	Description
EST tests	Press ACCEPT to proceed. Respond to the prompts, as indicated in Section 3.4.3, until the name of the first EST test is displayed.
name of EST test Run test ? CLEAR (N) ACCEPT (Y)	Press ACCEPT to run this test, or press CLEAR to skip to the next test. If you choose to run the test, the test's pass/fail status is displayed at the end of the test.

Message window display	Description
EST finished testing	Press ACCEPT to proceed.
Unblock wye	Remove stopper from patient wye. Press ACCEPT. The ventilator now runs POST and is ready for ventilation. To return to the service menu, hold down the MENU key while POST is running.

4.2.3.2.2 Calib/Other tests

This function lets you perform various subassembly calibrations or calibration checks and run miscellaneous other tests.

To access the *Calib/Other tests* functions from the **Run tests** prompt, turn the knob until **Calib/Other tests** is displayed, then press ACCEPT. Then turn the knob to locate the desired *Calib/Other tests* function. Upon entry to any of the tests, watch the message display window for prompting.

NOTE:

> The *Calib/Other tests* function is different from the *Update constants* function. Use the *Calib/Other tests* function to perform actual calibrations. Use the *Update constants* function to manually input calibration constants into NVRAM. The applicable repair procedures tell you which function to use.

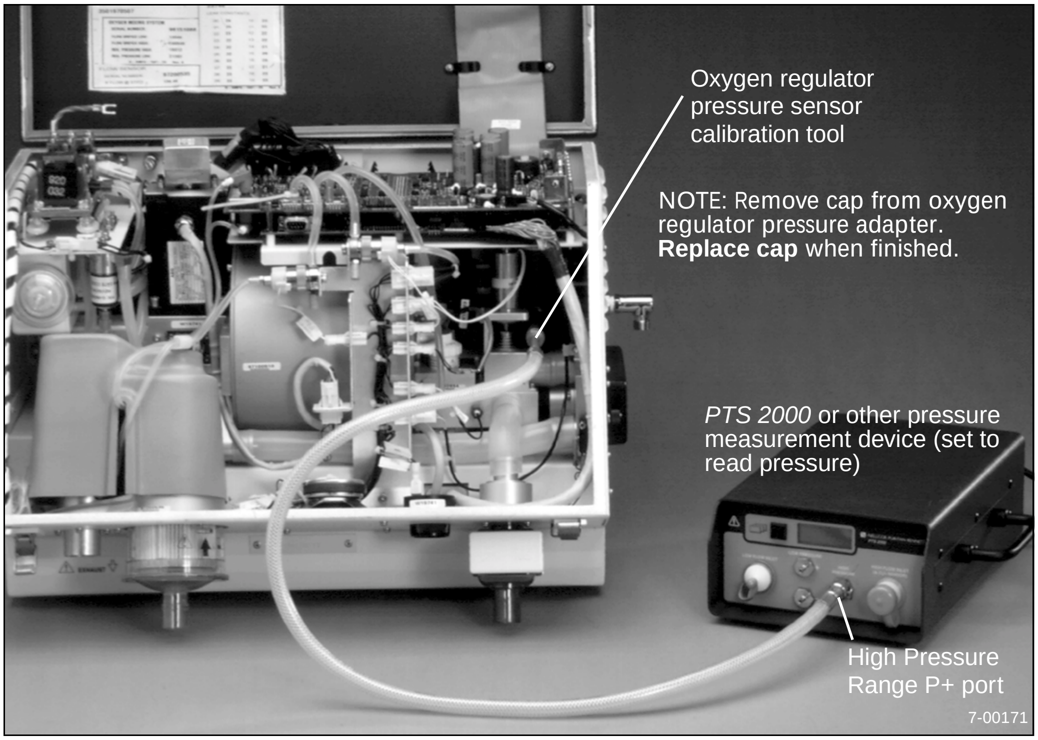
O2 pressure calib: Calibrating the oxygen regulator pressure transducer. This function lets you calibrate the oxygen regulator pressure transducer. It requires a pressure measurement device (for example, the *PTS 2000* or *RT-200*) and an oxygen regulator pressure transducer calibration tool (use tool P/N 4-079050-00 with the *PTS 2000*, or G-061541-00 with the *RT-200*).

Message window display	Description
O2 pressure calib	Press ACCEPT to perform this calibration. NOTE: If you do not wish to perform this calibration, do not proceed, but press CLEAR now. If you press ACCEPT now, the calibration cannot be exited until complete.
O2 pressure calib Connect test gauge	Tee in a pressure measurement device, as shown in Figure 4-3. Press ACCEPT to signify the measurement device is connected. Warning To prevent possible injury, do not remove the dust cap from the oxygen regulator access valve (brass part protruding from the side of the regulator) when the regulator is pressurized. If the access valve is not tightened, the valve may fly off when the dust cap is removed.
O2 pressure calib Disconnect O2 supply	Disconnect oxygen supply from ventilator. Press ACCEPT to signify the disconnection is complete.

Message window display	Description
O2 pressure calib Verify gauge = 0 psi	Verify that the pressure is reading zero (that is, no residual pressure), using the external measurement device. Press ACCEPT to proceed.
O2 pressure calib Reconnect O2 supply	Reconnect oxygen supply to ventilator. Press ACCEPT to signify the connection is complete.
O2 pressure calib Verify gauge >=15psi	This prompt appears if oxygen pressure is below 15 psi. Check that the oxygen supply is reconnected, then use the external measurement device to verify a pressure reading of at least 15 psi. Press ACCEPT to proceed.
O2 pressure calib Enter reg pressure 30.0 psi 2.067 bar	Turn the knob to enter the reading from the pressure measurement device. Press ACCEPT to signify the entered value is correct.
O2 pressure calib Verify reg pressure *xx.x* psi *x.xxx* bar	Press ACCEPT if the value displayed matches the pressure measurement device reading entered above, ±0.2 psi; otherwise, press CLEAR.
O2 pressure calib Disconnect tst gauge	Remove pressure measurement device and **replace cap**. Press ACCEPT.
O2 pressure calib Calibration passed *or* Calibration failed	If the calibration passes, press ACCEPT to return to the *Calibration tests* menu. If you do not intend to perform any other calibration functions, turn the knob to access **Exit testing**; otherwise, turn the knob to access another calibration function. If the calibration fails, try the following corrective actions: 1. Verify that oxygen supply pressure is between 40 and 90 psi (275 and 620 kPa). 2. Repeat this test and verify that oxygen is disconnected and reconnected when prompted. 3. Verify that oxygen regulator pressure transducer is securely connected to main ventilator head harness. 4. Replace oxygen regulator pressure transducer and recalibrate. 5. Replace pressure solenoid PCB. NOTE: If the ventilator was functioning correctly before service, but the calibration fails, it is unlikely that a PCB is malfunctioning.

If you selected **Exit** testing, do the following:

Message window display	Description
Exit testing	Press ACCEPT to reset the ventilator and exit the service menu in preparation for ventilation.


Oxygen regulator pressure sensor calibration tool
PTS 2000 or other pressure measurement device (set to read pressure)
High Pressure Range P+ port
7-00171

NOTE: Remove cap from oxygen regulator pressure adapter. **Replace cap** when finished.

Figure 4-3. Oxygen regulator pressure transducer calibration setup

FIO_2 sensor calib: Checking the oxygen sensor calibration. This function lets you perform a calibration check of the oxygen sensor. **It requires an oxygen source of at least 50 psi (345 kPa).**

Warning

Never perform the oxygen calibration check in an oxygen-enriched environment. This could result in improper calibration, yielding incorrect oxygen percentage readings.

Message window display	Description
FIO2 sensor calib	Press ACCEPT to perform this calibration check. NOTE: • If you do not wish to perform this calibration check, do not proceed, but press CLEAR now. If you press ACCEPT now, the calibration check cannot be exited until complete. • You can calibrate the oxygen sensor from the service menu (as described here) or the main menu (using the *Oxygen sensor* function).

Message window display	Description
FIO2 sensor calib Please wait...	Wait while the calibration check proceeds.
FIO2 sensor calib Calibration passed *or* Calibration failed	If the calibration passes, press ACCEPT to return to the *Calibration tests* menu. If you do not intend to perform any other calibration functions, turn the knob to access **Exit testing**; otherwise, turn the knob to access another calibration function. If the calibration check fails, try the following corrective actions: 1. Verify that oxygen supply pressure is at least 50 psi (345 kPa). 2. Check harness connections between oxygen sensor and ventilator main head harness. 3. Rerun calibration check. 4. Replace oxygen sensor and repeat calibration check. 5. Replace pressure solenoid PCB. NOTE: If the ventilator was functioning correctly before service, but the calibration fails, it is unlikely that a PCB is malfunctioning.

If you selected **Exit** testing, do the following:

Message window display	Description
Exit testing	Press ACCEPT to reset the ventilator and exit the service menu in preparation for ventilation.

Peep pump calib: Calibrating the PEEP pump. This function lets you calibrate the PEEP pump. It requires a PEEP pump calibration tool (P/N G-061540-00).

Message window display	Description
Peep pump calib	Press ACCEPT to perform this calibration. NOTE: If you do not wish to perform this calibration, do not proceed, but press CLEAR now. If you press ACCEPT now, the calibration cannot be exited until complete.
Peep pump calib Connect PEEP tubing to Pe transducer	Make the tubing connections as shown in Figure 4-4. Press ACCEPT to signify you have finished making the connections.
Peep pump calib Please wait...	Wait while the calibration proceeds. Caution The PEEP pump calibration takes approximately 5 minutes and 20 seconds. Touching the PEEP pump armature can cause an incorrect or failed calibration.
Peep pump calib Calibration complete Reconnect tubing	Return the tubing to its normal configuration. Press ACCEPT.
Peep pump calib Calibration passed *or* Calibration failed	If the calibration passes, press ACCEPT to return to the *Calibration tests* menu. If you do not intend to perform any other calibration functions, turn the knob to access **Exit** testing; otherwise, turn the knob to access another calibration function. If the calibration fails, try the following corrective actions: 1. Verify that tubing setup is correct. 2. Verify that voltage to PEEP pump is between +23 and +25 V. 3. Rerun calibration. 4. Verify that PEEP reservoir intake filter is not occluded; replace as required. 5. Replace PEEP pump and repeat calibration.

If you selected **Exit testing**, do the following:

Message window display	Description
Exit testing	Press ACCEPT to reset the ventilator and exit the service menu in preparation for ventilation.

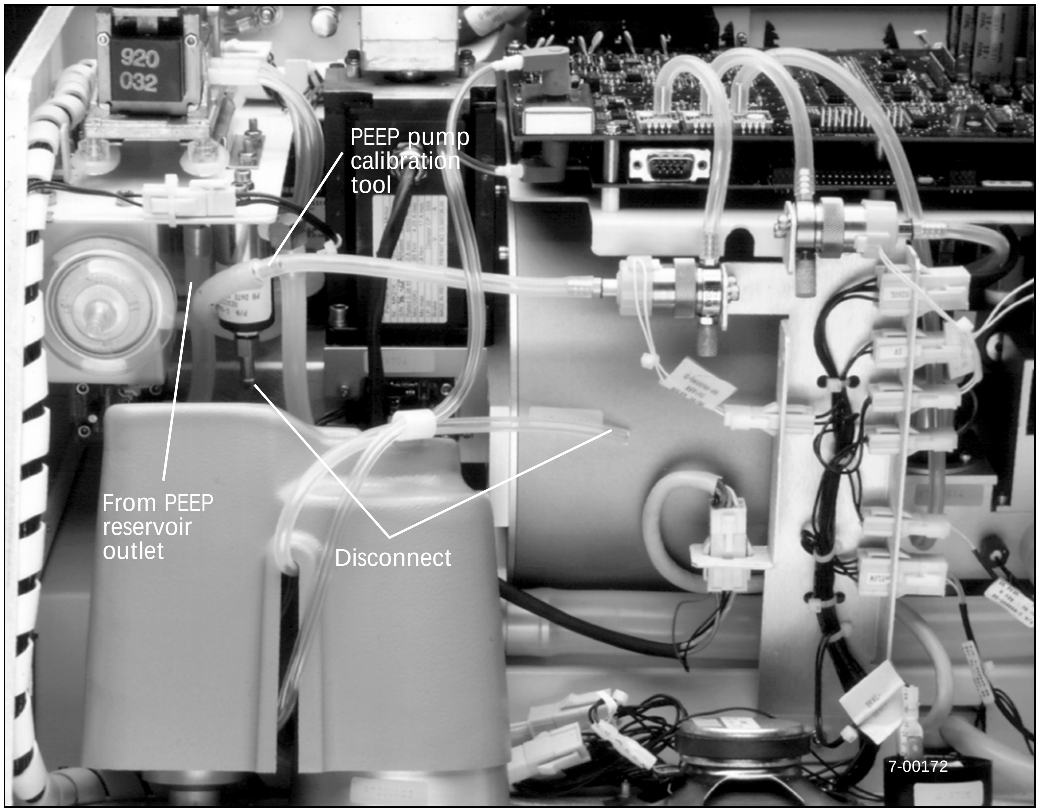


Figure 4-4. PEEP pump calibration setup

P_e P_{cyl} gain calib: Equalizing the gain of the exhalation and cylinder pressure transducers. This function lets you calibrate the exhalation and cylinder pressure transducers. It requires a P_eP_{cyl} kit (P/N G-061557-00).

Message window display	Description
Pe Pcyl gain calib	Press ACCEPT to perform this gain equalization. NOTE: If you do not wish to perform this gain equalization, do not proceed, but press CLEAR now. If you press ACCEPT now, the gain equalization cannot be exited until complete.
Pe Pcyl gain calib Connect syringe	Set up the ventilator, as shown in Figure 4-5. Press ACCEPT to signify you have finished.
Pe Pcyl gain calib Press to 50+/-5cmH2O Meas press= 0 cmH2O	Pressurize the syringe to 50 cmH_2O, as read in the message window and the LED bar graph. Press ACCEPT to signify the measured pressure has reached 50 cmH_2O.

Message window display	Description
Pe Pcyl gain calib Disconnect syringe	Return the tubing to its normal configuration. Press ACCEPT.
Pe Pcyl gain calib Calibration passed *or* Calibration failed	If the calibration passes, press ACCEPT to return to the *Calibration tests* menu. If you do not intend to perform any other calibration functions, turn the knob to access **Exit testing**; otherwise, turn the knob to access another calibration function. If the calibration fails, try the following corrective actions: 1. If the ventilator displays the message **App press too high** or **App press too low**, press ACCEPT to return to the **Calib/Other tests** prompt. Rerun equalization. 2. Verify that test setup is correct. 3. Rerun equalization. 4. Replace pressure solenoid PCB. NOTE: If the ventilator was functioning correctly before service, but the calibration fails, it is unlikely that a PCB is malfunctioning. 5. Replace controller PCB.

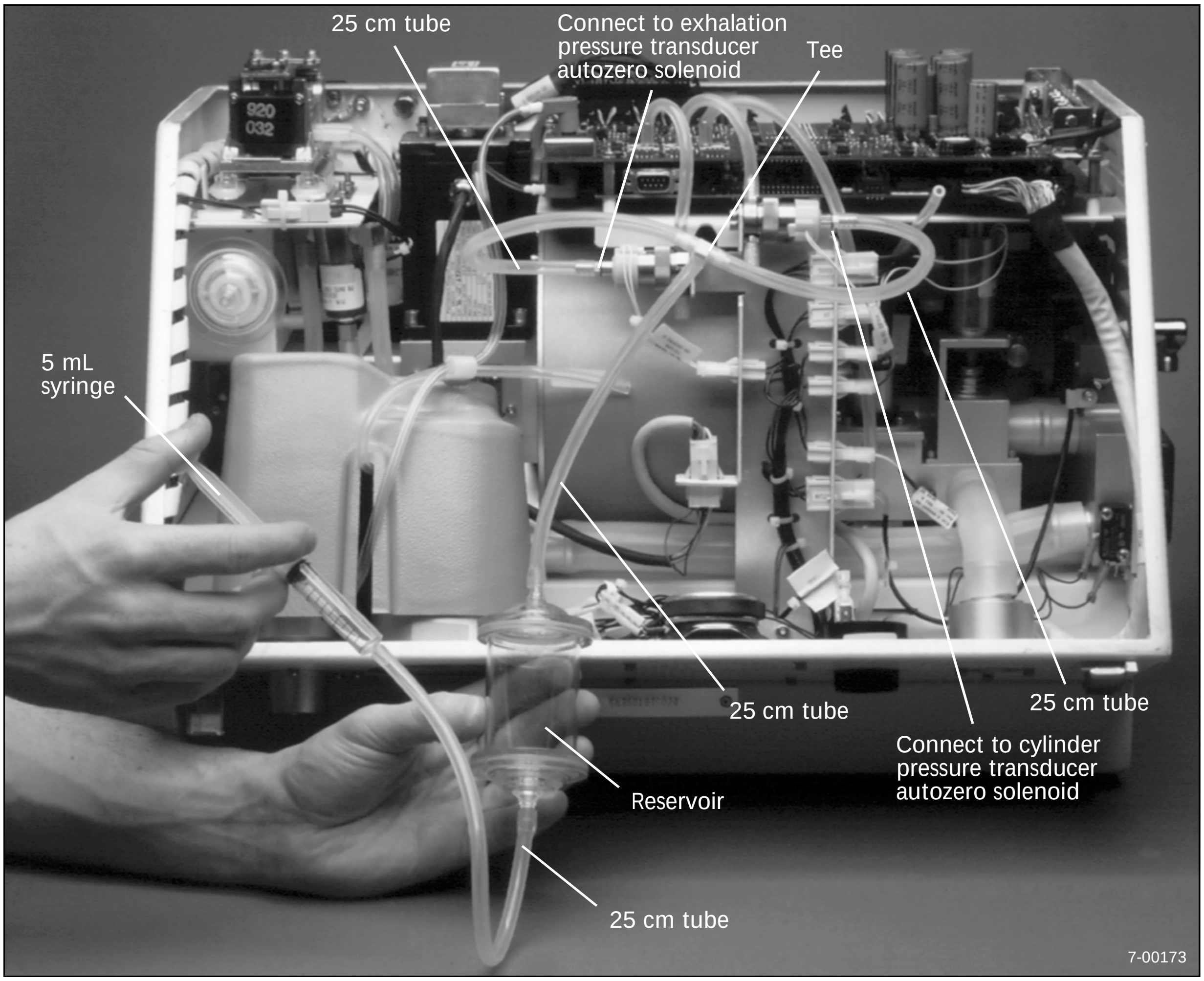

25 cm tube
Connect to exhalation pressure transducer autozero solenoid
Tee
5 mL syringe
25 cm tube
25 cm tube
Connect to cylinder pressure transducer autozero solenoid
Reservoir
25 cm tube
7-00173

Figure 4-5. P_e P_{cyl} **gain equalization setup**

Battery load test: This function allows the battery to be tested for at least 20 minutes of power. It requires a no. 3 inspiration port stopper (P/N G-061575-00). The initial voltage should be ≥ 24 V.

Message window display	Description
Battery load test	Press ACCEPT to perform test.
Battery load test Disconnect AC power if connected	Disconnect the ac power. Press ACCEPT. Test fails immediately if AC power remains connected.
Int battery test *or* Ext battery test Block insp filt port ACCEPT to proceed	Ventilator determines which battery is supplying power and lights the appropriate indicator. Block inspiratory filter port. Press ACCEPT to continue.

Message window display	Description
Int battery test *or* Ext battery test xx.x V Please wait...	Displays current voltage, updated every second. Test fails after first piston stroke if inspiratory port remains unblocked. Test continues until complete or voltage drops below limits. (Voltage limits: ≥24 V initially, ≥23 V during first piston stroke, and ≥21 V for remaining nine piston strokes.)
Int battery test *or* Ext battery test Reconnect AC power Reconnect I tubing	Reconnect inspiratory tubing. Verify that AC battery charging indicator string is illuminated when AC is connected.
Battery load test Test passed *or* Test failed ACCEPT to proceed	Press ACCEPT to return to the Calib/Other tests menu.

Serial ports test: This function allows you to test the functionality of the serial communications hardware (if present).

Message window display	Description
Serial ports ACCEPT to proceed	Press ACCEPT to perform test.
Connect port A to B	Connect the ports.
Serial ports test Test passed ACCEPT to proceed	Press ACCEPT to complete the test.
If serial communications NOT present: Serial ports test Are ports present? Clear (N) Accept (Y)	Press CLEAR to pass test, then press ACCEPT to complete the test.

Reg altitude calib: Adjusting the oxygen regulator for use at high or changing altitudes. This function adjusts the oxygen regulator pressure to achieve the lowest allowable oxygen mixing flow from the high-flow solenoid, which reduces noise from the high-flow solenoid during oxygen mixing. Perform this adjustment if:

- The ventilator is to be used at altitudes of 1,000 meters (3300 feet) or higher (atmospheric pressure of 915 cmH_2O or lower). Failure to perform this adjustment when relocating from lower to higher altitudes may result in excessively noisy ventilator operation but does not affect performance.
- The ventilator was previously adjusted for high-altitude operation and is now to be used an altitude that is lower by 500 meters (1600 feet) or more (an atmospheric pressure increase of 50 cmH_2O or more). Failure to perform this adjustment when relocating from higher to lower altitudes may result in inadequate oxygen supply pressure and one or both of these alarms: **LOW O2 SUPPLY**, **O2% LOW**.

NOTE:

To display atmospheric pressure (Pa), enter the Service menu, then press ACCEPT to select each of the following functions:

Sensor data
Pressure sensors
Pa

Caution

To help avoid triggering **LOW O2 SUPPLY** or **O2% LOW** alarms, perform the Reg altitude calib using the lowest oxygen supply pressure and most restrictive oxygen hose and adapters that will be used during normal ventilation.

To avoid the possibility of entering a ventilator inoperative condition or damaging the regulator, do not power down the ventilator during this adjustment. However, in case of power loss to the ventilator during adjustment, follow these steps:

- Use a pressure gauge to ensure that regulator pressure is below 38 psi (the ventilator will not pass POST if regulator pressure is above 38 psi).
- At power-up, support the oxygen regulator to prevent the piston rack from hitting the regulator.
- Once ventilator power is restored, perform the entire Reg altitude calib.
- Replace the inspiratory access panel at the end of the adjustment to support the oxygen regulator.

You need a 3/16-in. open or box-end wrench, a 3/8-in. open or box-end wrench, and #1 and #2 POZIDRIV screwdrivers to perform this adjustment.

Message window display	Description
Reg altitude calib	Press ACCEPT to begin this adjustment.
Reg altitude calib Is Po calibrated? CLEAR (N) ACCEPT (Y)	Press ACCEPT if you performed an O2 pressure calib during this service session, or press CLEAR if you have not yet performed an O2 pressure calib. If you press ACCEPT, there is a one-second burst from the high-flow solenoid.
Reg altitude calib Perform Po calib ACCEPT to proceed	If you pressed CLEAR at the previous prompt to indicate that you have not yet performed an O2 pressure calib during this service session, this message appears to tell you to perform that adjustment first. Press ACCEPT to exit the Reg altitude calib, then turn the knob to select *O2 pressure calib*.
Reg altitude calib Excessive Po droop ACCEPT to proceed	This prompt appears following the one-second high-flow solenoid burst if there is an oxygen supply problem (oxygen regulator pressure dropped below 4 psi during the burst), such as a disconnected or restricted supply or inadequate supply pressure. Press ACCEPT to exit the Reg altitude calib, then resolve the oxygen supply problem.
High Flow=xxx L/min Calib not required Po=xx.x psi	This prompt appears if the Reg altitude calib is not required, and indicates that the flow from the high-flow solenoid already set properly, and that the adjustment is not required. (*High Flow* is the measured flow during the test burst, and *Po* is the oxygen regulator pressure.) Press ACCEPT to exit the Reg altitude calib.
High Flow=xxx L/min Remove insp panel ACCEPT to proceed	This prompt appears following the one-second high-flow solenoid burst if the Reg altitude calib is required. Remove the inspiration access panel and air intake manifold assembly (Section 8.6.6) to access the oxygen regulator. (Leave the oxygen regulator in place, supported by the nozzles.) Press ACCEPT to continue or CLEAR to abort the adjustment.
High Flow=xxx L/min Calibration aborted	If you pressed CLEAR at the previous prompt to indicate that you want to abort the Reg altitude calib, this message appears. Press ACCEPT to exit the adjustment.
High Flow=xxx L/min Adjust to xx.x psi Po=xx.x psi	When you see this message, turn the 3/8-in. wrench counterclockwise to loosen the lock nut at the top of the oxygen regulator, then use the 3/16-in. wrench to turn the adjustment screw at the top of the regulator and adjust regulator pressure to the displayed value as shown in Figure 4-6 (turning the screw counterclockwise reduces pressure). The message *Po=xx.x psi* shows the real-time regulator presure as you make this adjustment. Press ACCEPT once you have adjusted regulator pressure.
High Flow=xxx L/min Reg pres unchanged ACCEPT to proceed	This message indicates that oxygen regulator pressure remained within 0.2 psi of the initial pressure (that is, that regulator pressure was not adjusted). Use the 3/8-in. wrench to re-tighten the lock nut at the top of the oxygen regulator. Press ACCEPT to exit the adjustment.

Message window display	Description
High Flow=xxx L/min Default pressure set Replace insp panel	This message indicates that regulator pressure has been reset to the factory default value of 33 ± 2 psi. Use the 3/8-in. wrench to re-tighten the lock nut at the top of the oxygen regulator. Replace the inspiratory access panel, then press ACCEPT to exit the adjustment.
High Flow=xxx L/min Calibration passed Replace insp panel	This message indicates that the Reg altitude calib was successful. Use the 3/8-in. wrench to re-tighten the lock nut at the top of the oxygen regulator. Replace the inspiratory access panel, then press ACCEPT to exit the adjustment. If the calibration passes, press ACCEPT to return to the *Calibration tests* menu. If you do not intend to perform any other calibration functions, turn the knob to access **Exit testing**; otherwise, turn the knob to access another calibration function.

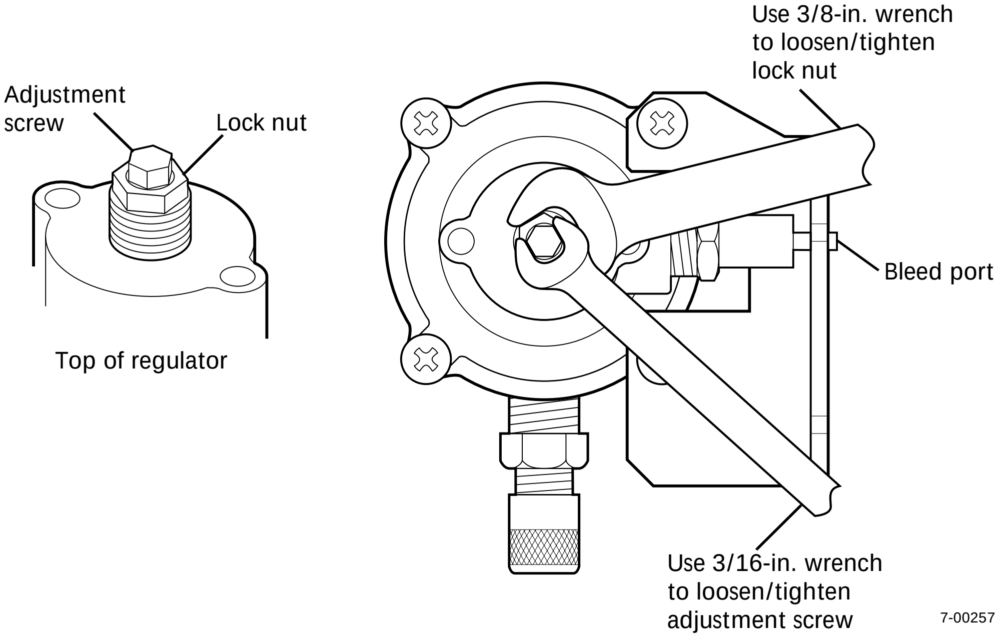

Adjustment screw
Lock nut
Top of regulator
Use 3/8-in. wrench to loosen/tighten lock nut
Bleed port
Use 3/16-in. wrench to loosen/tighten adjustment screw
7-00257

Figure 4-6. Adjusting oxygen regulator pressure

If you selected **Exit** testing, do the following:

Message window display	Description
Exit testing	Press ACCEPT to reset the ventilator and exit the service menu in preparation for ventilation

4.2.3.3 Clear test log: Erasing the test log

This function lets you erase all diagnostic codes from the test log.

Message window display	Description
Clear test log	Press ACCEPT to erase all diagnostic codes from the test log.
Clear test log Log cleared	Press ACCEPT.

4.2.3.4 Clear alert log: Erasing the alert log

This function lets you erase all diagnostic codes from the alert log.

Message window display	Description
Clear alert log	Press ACCEPT to erase all diagnostic codes from the alert log.
Clear alert log Log cleared	Press ACCEPT.

4.2.3.5 Update constants: Manually inputting calibration constants into NVRAM.

This function lets you manually input calibration constants into NVRAM. It is intended for use when installing a new oxygen solenoid assembly, flow sensor, or piston/cylinder assembly.

NOTE:

Always set the calibration constants to the values listed on the calibration constants label for the applicable part.

Message window display	Description
Update constants	Press ACCEPT to proceed.
Update oxygen mixing *or* Update flow sensor *or* Update piston *or* Update prsol nvram	Turn the knob to locate the desired category of calibration constant and select by pressing ACCEPT. **Caution** To ensure correct function of the pressure solenoid PCB, if you perform the Update prsol nvram function, you must then perform the **O2 pressure calib** and **FIO2 sensor calib** functions.

Message window display	Description
specific calibration constant *value of constant* Turn knob to adjust	Turn the knob to adjust the constant's value. For all constants (except piston leak constants), the adjustment is a two-step process. First, use the knob to perform a coarse adjustment (that is, to adjust the hundreds or the whole number, in the case of a decimal number). Press ACCEPT when this coarse adjustment is complete. Then use the knob to perform a fine adjustment (that is, to adjust the ones or the decimal part of the number). Press ACCEPT when this fine adjustment is complete. NOTE: If you need to perform only the fine adjustment, you must still press ACCEPT to proceed to the fine adjustment.
Update new constants Are you sure? CLEAR (N) ACCEPT (Y)	Press ACCEPT to write the new constants to NVRAM. If applicable, be sure to affix the small calibration constants label for the new part atop the larger calibration constants label on the lid.
Cycle power then perform FIO2 calib and O2 press calib	This prompt appears at thend of the **Update prsol nvram** update, and indicates that you should turn the ventilator off, then back on, and perform **FIO2 calib** and **O2 press calib** (Section 4.2.3.2.2).

4.2.3.6 Review constants: Viewing calibration constants in NVRAM

This function lets you view calibration constants in NVRAM.

Message window display	Description
Review constants	Press ACCEPT to proceed.
Review oxygen mixing *or* Review flow sensor *or* Review piston	Turn the knob to locate the desired category of calibration constant and select by pressing ACCEPT.
specific calibration constant *value of constant* Press CLEAR to exit	Turn the knob to view the value of each calibration constant in this category. Press ACCEPT or CLEAR to return to the previous (**Review...**) prompt.

4.2.3.7 Reset service data

When you install a new internal battery, this function resets that part's life expectancy value, which is stored in NVRAM. When you perform a regularly scheduled service, this function lets you change the number of hours until the next service, which is also stored in NVRAM. The ventilator uses these new values to update the ventilator's Service summary display (function 10). This function also allows you to update the ventilator serial number.

Message window display	Description
Reset service data	Press ACCEPT to proceed.
Reset battery in use *or* Reset next service *or* Reset serial number	Turn the knob as required to locate the desired type of service data. Press ACCEPT to select it.

If you selected **Reset battery in use**, you will see this display:

Message window display	Description
Reset battery in use *or* Are you sure? CLEAR (N) ACCEPT (Y)	Press ACCEPT to reset the hours of *internal* battery life.

If you selected **Reset next service**, you will see this display:

Message window display	Description
xxxxx hours	Turn the knob to adjust the number of hours until the next service. Press ACCEPT to proceed.

If you selected **Reset serial number**, you will see this display:

Message window display	Description
Update serial number	Press ACCEPT to proceed.
Vent serial number xxxxyyzzzz Turn knob to adjust	Turn the knob to set the year of manufacture (the flashing fifth and sixth digits). Press ACCEPT to proceed. NOTE: The first four digits of the serial number are not adjustable. The years 2000 and later are shown as *00*, *01*, etc.
Vent serial number xxxxyyzzzz Turn knob to adjust	Turn the knob to set the next two digits (the flashing seventh and eighth digits). Press ACCEPT to proceed.
Vent serial number xxxxyyzzzz Turn knob to adjust	Turn the knob to set the last two digits (the flashing ninth and tenth digits). Press ACCEPT to proceed.
Serial number OK? xxxxyyzzzz CLEAR (N) ACCEPT (Y)	Press ACCEPT to reset the serial number in NVRAM or CLEAR to return to *Update serial number*.

4.2.4 Review alert log: Reading the alert log

NOTE:

> All service functions can be accessed while the ventilator is not ventilating. When ventilating, the only function accessible is the *sensor data* function.

This function lets you read the diagnostic codes in the alert log.

To access this function from the **A.Service menu** prompt, turn the knob until **Review alert log** is displayed.

Message window display	Description
Review alert log	Press ACCEPT to proceed.
Log entries	Review the first entry in the log, referring to Figure 4-7. Turn the knob to scroll through all remaining entries. Press CLEAR to exit.

```
aa) bbbbb-cc-d eee
date           time
```

where:		
	aa	is the error's position in the log (1=the most recently detected)
	bbbbb	is the code number (see Section 4 to interpret)
	cc	is the identifier of the task being run at the time the condition was detected
	d	is the identifier of the subsystem in which the condition was detected
	eee	is the number of consecutive occurrences of the condition
	date	is the month, day, and year the condition was detected
	time	is the hour and minute when the condition was detected

Figure 4-7. Test and alert log format

4.2.5 Test data: Reading the test log or EST test results

NOTE:

> All service functions can be accessed while the ventilator is not ventilating. When ventilating, the only function accessible is the *sensor data* function. You can also run EST from the main menu.

This function displays the contents of the test log entries or the EST test results.

To access the *Test data* functions from the **A.Service menu** prompt, turn the knob until **Test data** is displayed, then press ACCEPT. Then turn the knob to locate the desired *Test data* function.

4.2.5.1 Review test log: Reading the test log

This function lets you read the diagnostic codes in the test log.

Message window display	Description
Review test log	Press ACCEPT to proceed.
log entries	Review the first entry in the log, referring to Figure 4-7. Turn the knob to scroll through all remaining entries.

4.2.5.2 Review EST tests: Reading pass/fail status of EST tests

This function lets you read the pass/fail status of all tests during the most recent EST.

Message window display	Description
Review EST tests	Press ACCEPT to proceed.
EST test result	Review the entries in the test log or the individual EST test results, referring to Figure 4-7 (for test log entries) or Section 3.4 (for EST test results). Turn the knob to scroll through remaining entries.

4.3 Utilities functions

4.3.1 Pressure format

This function lets you choose the unit for display of pressures (cmH_2O or hPa).

Message window display	Description
Pressure format	Press ACCEPT to proceed.
cmH2O *or* hPa	Turn the knob to choose either cmH_2O or hPa, then press ACCEPT to select it. The ventilator now runs POST to reset all parameters to the appropriate units.

4.3.2 Date and time format

This function lets you choose the format for display of the date (European or US) and time (12- or 24-hour clock).

Message window display	Description
Date & time format	Press ACCEPT to proceed.
Time format select *or* Date format select	Turn the knob to choose either Time format select or Date format select, then press ACCEPT to proceed. NOTE: Regardless of the selected date format, the years 2000 and later are shown as *00*, *01*, etc.

If you selected **Time format select**, you will see this display:

Message window display	Description
12 hour format *or* 24 hour format	Turn the knob to choose either 12-hour format or 24-hour format, then press ACCEPT to select it.

If you selected **Date format select**, you will see this display:

Message window display	Description
US date format *or* Europe date format	Turn the knob to choose either US date format or Europe date format, then press ACCEPT to select it.

Performance verification

Conduct these tests to verify the performance of the *700 Series Ventilator System*.

NOTE:

- The *700 Series* Ventilator System is manufactured with accurate pneumatic and electronic test equipment in a controlled environment. As field conditions vary, the accuracy of measurement devices becomes less certain.
  The following test specifications were established with the test equipment specified in Table 5-2. If the accuracies of your institution's test equipment differ from those listed, please make applicable allowances.
- The procedures in this section do not apply to ventilator accessories. Refer to operator's or service manuals of the accessories. Malfunctioning accessories may affect some ventilator functions and may result in false test results.
- Refer to this section when performing the safety checks recommended in the *700 Series Ventilator System Operator s Manual*.

5.1 When to run

Run the performance verification or portions of it after servicing the ventilator (Table 5-1).

Table 5-1: When to run performance verification

Interval or service performed	Test requirements
Every year or per your hospital's protocol	Test 1 (electrical safety test)
15,000-hour preventive maintenance	Complete performance verification
30,000-hour preventive maintenance	Complete performance verification
Removal/replacement of line filter, circuit breaker, power switch, power supply, or power assembly harnesses	Test 1 (electrical safety test) and test 6 (EST)
Removal/replacement of rotary encoder	Test 2 (rotary encoder test) and test 6 (EST)
Removal/replacement of piston/cylinder assembly, gear meshing, or greasing of rack	Test 5 (gas volume accuracy, breath timing, and PEEP system test) and test 6 (EST)
Removal/replacement of motor/encoder assembly, PEEP pump, or flow sensor assembly	Test 5 (gas volume accuracy, breath timing, and PEEP system test) and test 6 (EST)
Removal/replacement of oxygen regulator, oxygen solenoid assembly, oxygen regulator pressure transducer, mixing manifold, or oxygen sensor	Test 6 (EST) and test 7 (oxygen accuracy test)
Removal/replacement of safety valve assembly	Test 6 (EST) and test 9 (safety valve test)
Removal/replacement of UI display, pressure solenoid, controller, or battery backup (BBU) PCB; installation/removal/replacement of the Communications option assembly; EPROMs; or NVRAM	Complete performance verification
Removal/replacement of any other part	Test 6 (EST)

5.2 Tools, test equipment, and service materials

In addition to the tools listed in Section 1, the test equipment and materials listed in Table 5-2 are required for the performance verification.

Table 5-2: Test equipment required for performance verification

Description	Manufacturer and model or Nellcor Puritan Bennett part number
Electrical safety analyzer, capable of measuring ground resistance and leakage current	BIO-TEK Model 601 PRO or equivalent
Pneumatic calibration analyzer or equivalent devices capable of measuring oxygen percent, flow, BTPS volume, and pressure. Oxygen analyzer connector tee. Required accuracies: Flow: 2.75% of reading ±0.05 sL/min Volume: 2% of reading or ±1 digit Low pressure (-150 to +150 cmH_2O): 0.75% of reading ±0.04 cmH_2O High pressure (0 to 150 psig): 1.0% of reading ±0.1 psi Oxygen percentage: ±2% oxygen	Nellcor Puritan Bennett *PTS 2000* Performance Test System (4-074686-00) or Timeter RT-200 Calibration Analyzer, Allied Healthcare Products, Inc., 1720 Sublette Ave., St. Louis, MO 63110 USA, 1-800-444-3940. NOTE: If you use the RT-200, you also need a separate oxygen analyzer.
Digital multimeter (DMM) accurate to three decimal places	Local supplier
Multimeter patch cord set, 0.025 square receptacle (Includes red cord (P/N G-061579-00) and black cord (P/N G-061580-00))	G-061567-00 or equivalent
Ventilator breathing circuit	To use as test circuit: G-061208-00 or equivalent (adult, reusable, without heated wire) NOTE: To ensure that compliance compensation functions correctly, you must run EST or SST with the circuit configured as intended for use on the patient.
Test lung with strap	4-000612-00
Tubing kit, performance verification (Includes coupling (P/N 4-003443-00), tube junction connector (P/N 4-011521-00) (quantity of 2), and 30-cm, 3/16-in. ID x 3/8-in. OD tubing)	G-061573-00
Stopper, wye (no. 2)	G-061574-00 or local supplier
Stopper, inspiration port (no. 3)	G-061575-00 or local supplier
Oxygen source (40 to 90 psi (275 to 620 kPa))	Local supplier

Table 5-2: Test equipment required for performance verification (continued)

Description	Manufacturer and model or Nellcor Puritan Bennett part number
Static-dissipative field service kit (includes wrist strap, static-dissipative mat, and ground cord)	G-061661-00 or equivalent
ESD-safe vacuum cleaner with 0.2 μm filter (rated for photocopiers and laser printers)	Local supplier

5.3 Preliminary ventilator cleaning and inspection

Warning

To prevent disease transmission, use personal protective equipment when handling contaminated bacterial filters or other patient accessories. Refer to the *700 Series Ventilator Operator s Manual for instructions on sterilizing patient syst*em parts.

Caution

To prevent damage to ESD-sensitive components, always follow ESD guidelines when servicing components inside the ventilator.

NOTE:

If you find any problems during the preliminary ventilator inspection, correct them before proceeding with the performance verification. Failure to correct such problems now may affect the remainder of the performance verification.

Clean and inspect the ventilator as follows.

1. Clean ventilator exterior.
2. Remove any water from humidifier jar and dry the jar, if applicable.
3. Open and prop UI.
4. Using ESD-safe vacuum cleaner, clean interior of ventilator.
5. Remove and inspect main fan filter. Clean, vacuum, or replace as required.
6. Inspect outer gasket around lid to ensure it is not torn and that entire gasket is securely affixed to lid. Repair as needed.
7. Verify that oxygen regulator bleed port is installed to vent oxygen bleed gas through the louvers in the inspiration access panel.
8. Verify that the check valves in the air intake manifold are securely installed in the air intake manifold, and are not visibly worn or torn.
9. Verify that oxygen fitting is securely screwed into brass nut. (Brass nut will swivel, however.)

10. If you are regreasing the rack (every 15,000 hours and every time you install a new piston/cylinder assembly), inspect the rack and pinion for wear, chips, or breakage.
11. Visually inspect ventilator exterior and interior for obvious problems, such as missing or broken parts; loose assemblies; or disconnected wires, connectors, or tubing. Repair as needed.

5.4 Preliminary ventilator setup

Set up the ventilator for the performance verification as follows:

1. Install a complete Nellcor Puritan Bennett (or equivalent) ventilator breathing circuit. Verify that bacteria filters are installed.

NOTE:
A humidification device is not required for the performance verification or ventilation.

2. Connect ventilator to an oxygen source.

5.5 Preliminary pneumatic test equipment setup

To set up your pneumatic test equipment for use in the performance verification, verify that all equipment is calibrated and **sufficient warm-up time has elapsed prior to measurement.**

5.6 Performance verification procedures

To ensure systematic performance verification and logical fault diagnosis, perform these tests in the order given. If you need to repeat a test, however, the current control settings are completely defined at the beginning of each individual check.

NOTE:

- If you are running the performance verification tests in order, you need only make the ventilator settings shown in boldface.
- To locate the cause of a malfunction, note the boldfaced letter following the step and refer to the corresponding index letter in Section 5.7 (“Troubleshooting”).

Follow these general guidelines when running the performance verification:

- If you note a problem during the performance verification, verify that you followed the procedures correctly before attempting to repair the ventilator.
- Verify that you correctly entered the data on the ventilator UI by listening for the audible confirmation of accepted settings and observing the appropriate display.
- When making ventilator settings, be aware that because of interrelationships between some ventilator settings, you may not always be able to make all settings in the indicated sequence.

- Use the alarm silence and alarm reset keys to restore the ventilator to the test condition. Using these keys may be necessary because of the nonstandard set of tubing connections, which may cause apnea or other alarm conditions to occur.
- Except for the alarm silence and alarm reset keys, do not change the control settings during these procedures, unless specifically instructed.
- Refer to Section 8 for required repairs. When repairs are completed, repeat the test. When the test is successful, proceed with the next test, as applicable.

NOTE:

The following procedures do not verify the performance of accessories. Verify the performance of accessories using the appropriate procedures in the applicable operator's or service manual.

Warning

Follow accepted safety procedures for electrical equipment when making connections, adjustments, or repairs.

5.6.1 Electrical safety test and power-on self-test (POST) (Test 1)

Warning

If the ventilator fails an electrical safety test, do not proceed to the next electrical safety test until you correct the problem and retest the unit.

The electrical safety test verifies that ground resistance and leakage current are within safe limits. Perform this test whenever you service the ventilator, per your hospital's requirements. The power-on self-test (POST), in conjunction with the extended self-test (EST), verifies overall ventilator performance. POST is initiated automatically whenever power to the ventilator is turned on. For additional information about POST, refer to Section 3.

1. Verify that ventilator power is off.
2. Plug ventilator into electrical safety analyzer.
3. VERIFY ground resistance is < 0.2 Ω (including power cord supplied with ventilator). These test points are suggested: potential equalization point, one of the screws securing the speaker, one of the screws on the options panel, the brass nut of the DISS oxygen inlet fitting, and one of the unpainted catches on the lid (that mates with the buckle). **See Section 5.7 A.**
4. Turn on ventilator power.
5. VERIFY that POST passes (indicated by unit displaying **Accept settings to start ventilation**). **See Section 5.7 B.**
6. VERIFY that forward and reverse current leakage to ground is <300 µA (100/115 V units) or <500 µA (220/240 V units). **See Section 5.7 C.**
7. VERIFY that main fan is operating properly. **See Section 5.7 D.**
8. Power off ventilator.
9. Unplug ventilator from electrical safety analyzer. Plug ventilator into wall outlet.

5.6.2 Rotary encoder test (Test 2)

The rotary encoder test verifies that the rotary (knob) encoder is functioning properly.

1. Verify that ventilator power is on.
2. Make these ventilator settings:

Control	Setting
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	15 breaths/min
TIDAL VOLUME	200 mL
PEAK FLOW	30 L/min
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
% O_2	21

3. Select PEEP/CPAP.
4. Rotate knob one detent clockwise. VERIFY that the displayed PEEP/CPAP setting is 0.5 cmH_2O. **See Section 5.7 E.**
5. Continue rotating the knob nine more detents. VERIFY that for each detent the displayed PEEP/CPAP setting increases by 0.5 cmH_2O. **See Section 5.7 E.** VERIFY that after 10 detents, the PEEP/CPAP setting is 5 cmH_2O. **See Section 5.7 E.**
6. Turn off ventilator power.

5.6.3 Battery test (Test 3)

The battery test verifies that the batteries are operating correctly. Perform one of the following two tests: the external/internal battery test (Section 5.6.3.1) if the ventilator has an external battery or the internal battery test (Section 5.6.3.2) if the ventilator *does not* have an external battery.

NOTE:

If the optional external battery is not connected to the ventilator, perform the internal battery test only.

5.6.3.1 External/internal battery test

Perform this test only if the ventilator has an external battery connected.

1. Plug ventilator power cord into wall outlet.
2. Turn on power to ventilator.
3. Unplug power cord from wall outlet.
4. VERIFY that ventilator continues operating uninterrupted, that LOSS AC POWER alarm is invoked, and that ON EXTERNAL BATTERY indicator (in VENTILATOR STATUS section of UI) flashes. **See Section 5.7 F.**
5. Disconnect external battery from ventilator.
6. VERIFY that ventilator continues operating uninterrupted and that ON INTERNAL BATTERY indicator (in VENTILATOR STATUS section of UI) flashes. **See Section 5.7 F.**
7. Plug ventilator power cord back into wall outlet.
8. VERIFY that ON INTERNAL BATTERY indicator turns off within 3 seconds and that ON AC/BATTERY CHARGING indicator lights. **See Section 5.7 F.**
9. Press alarm reset key to clear CAUTION lamp and SWITCH INT BATTERY message.

5.6.3.2 Internal battery test

Perform this test only if the ventilator *does not* have an external battery connected.

1. Plug ventilator power cord into wall outlet.
2. Turn on power to ventilator.
3. Unplug power cord from wall outlet.
4. VERIFY that ventilator continues operating uninterrupted, that LOSS AC POWER alarm is invoked, and that ON INTERNAL BATTERY indicator (in VENTILATOR STATUS section of UI) flashes. **See Section 5.7 G.**
5. Plug ventilator power cord back into wall outlet.
6. VERIFY that ON INTERNAL BATTERY indicator turns off within 3 seconds and that ON AC/BATTERY CHARGING indicator lights. **See Section 5.7 G.**
7. Press alarm reset key to clear CAUTION lamp and LOSS AC POWER message.

5.6.4 Supply voltage test (Test 4)

The following procedures describe how to measure supply voltages off the pressure solenoid PCB.

Caution

To prevent possible damage to the pressure solenoid PCB, always use 0.025 square-receptacle banana plugs (see Table 5-2) when performing this test.

---

1. Open and prop ventilator lid.

NOTE:

The FAN FAILED ALERT alarm may be activated while the ventilator lid is open. Be sure to clear the associated code (6004) from the alert log after completing the performance verification.

---

2. Locate power supply/reference voltage test connector J2 on pressure solenoid PCB (Figure 5-1).

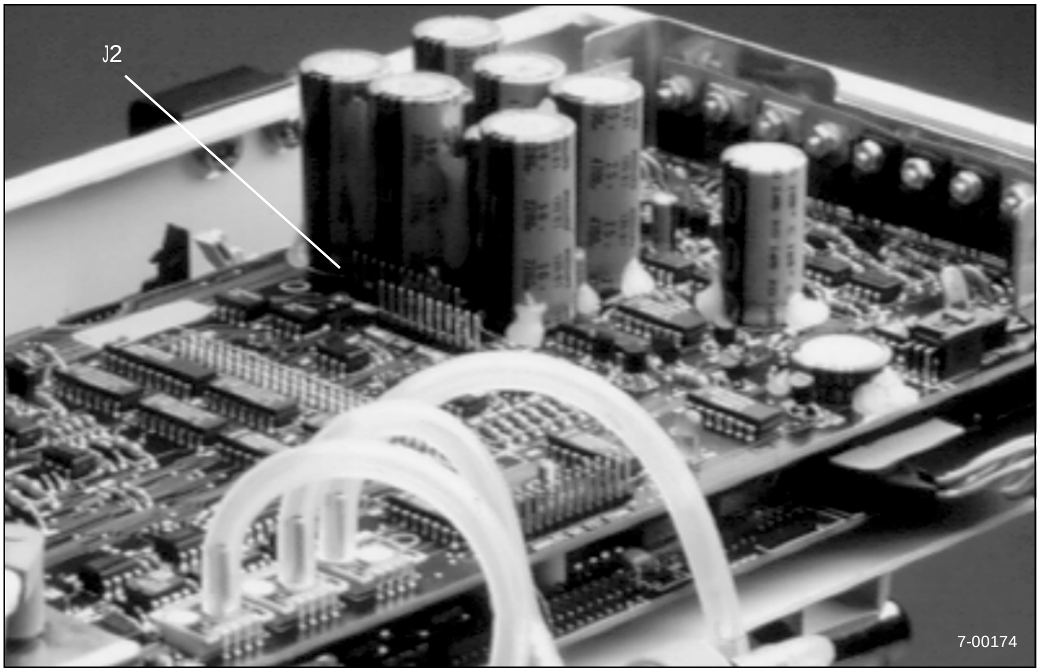


Figure 5-1. Power supply/reference voltage test connector J2 on pressure solenoid PCB

3. Connect DMM leads to each pair of pins given below, and VERIFY voltage readings given in Table 5-3. **See Section 5.7 I, J, K, L, M, N.**

Table 5-3: Pressure solenoid PCB test connector (J2) voltages

Voltage	Positive lead	Negative lead	Acceptable range
+24 V	1	12	23.00 to 25.00 V
-15 V	2	12	-15.27 to -14.09 V
+5 V	4	12	4.92 to 5.08 V
+1.2 V	5	12	1.23 to 1.24 V
UI-5 V	7	12	4.8 to 5.2 V
+15 V	11	12	14.32 to 15.57 V

4. Remove leads from test connector, and close ventilator lid.

5.6.5 Gas volume accuracy, breath timing, and PEEP system test (Test 5), using the RT-200 Pneumatic Calibration Analyzer

This test verifies the accuracy of the volume of gas delivered to the patient. It also verifies the breath timing and PEEP system.

1. When using the RT-200 Pneumatic Calibration Analyzer, set up the ventilator for test as shown in Figure 5-2.

NOTE:

If the selected humidification type is *dual heated wire* or *no heated wire*, verify that the BTPS measurement function on the RT-200 is activated (do not activate the BTPS measurement function if the humidification type is *HME*).

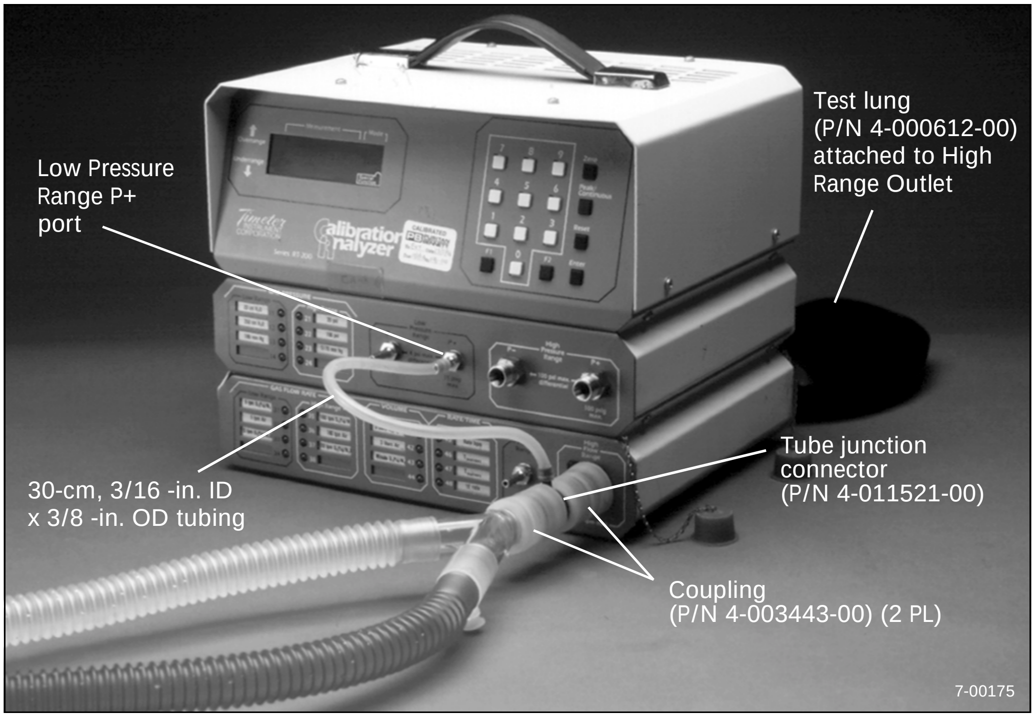

Low Pressure Range P+ port
Test lung (P/N 4-000612-00) attached to High Range Outlet
30-cm, 3/16 -in. ID x 3/8 -in. OD tubing
Tube junction connector (P/N 4-011521-00)
Coupling (P/N 4-003443-00) (2 PL)
7-00175

Figure 5-2. RT-200 Setup for Test 5

2. Change the ventilator settings shown in **bold**.

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**30 breaths/min**
TIDAL VOLUME	**100 mL**
PEAK FLOW	30 L/min
PLATEAU	0 s
PEEP/CPAP	**3 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21

3. Wait until ventilator delivers at least 10 breaths.

4. Make the following measurements, and VERIFY that the readings are as listed below. **See Section 5.7 O, P, Q.**

NOTE:

When measuring PEEP at high breath rates, the RT-200 reading fluctuates, making it difficult to take an accurate reading. To eliminate this difficulty, measure PEEP with the rate turned down to 3 breaths/min.

Measure the following	Acceptable range
Tidal volume	80 to 120 mL
Respiratory rate	29 to 31 breaths/min
PEEP	17.39 to 22.61 cmH_2O

5. Change the ventilator settings shown in **bold**.

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**20 breaths/min**
TIDAL VOLUME	**600 mL**
PEAK FLOW	**60 L/min**
PLATEAU	0 s
PEEP/CPAP	**15 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21

6. Make the following measurements, and VERIFY that the readings are as listed below: **See Section 5.7 O, P, Q**.

Measure the following	Acceptable range
Tidal volume	530 to 670 mL
Respiratory rate	19 to 21 breaths/min
PEEP	12.56 to 17.44 cmH_2O

7. Change the ventilator settings shown in **bold.**

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**10 breaths/min**
TIDAL VOLUME	**1000 mL**
PEAK FLOW	**80 L/min**
PLATEAU	0 s
PEEP/CPAP	**20 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21

8. Make the following measurements, and VERIFY that the readings are as listed below. **See Section 5.7 O, P, Q**.

Measure the following	Acceptable range
Tidal volume	890 to 1110 mL
Respiratory rate	9 to 11 breaths/min
PEEP	17.39 to 22.61 cmH_2O

9. Remove test setup, and return ventilator to original configuration.

5.6.6 Gas volume accuracy, breath timing, and PEEP system test (Test 5), using the *PTS 2000* and *Breathlab* software

This test verifies the accuracy of the volume and oxygen percentage of gas delivered to the patient. It also verifies the breath timing and PEEP system.

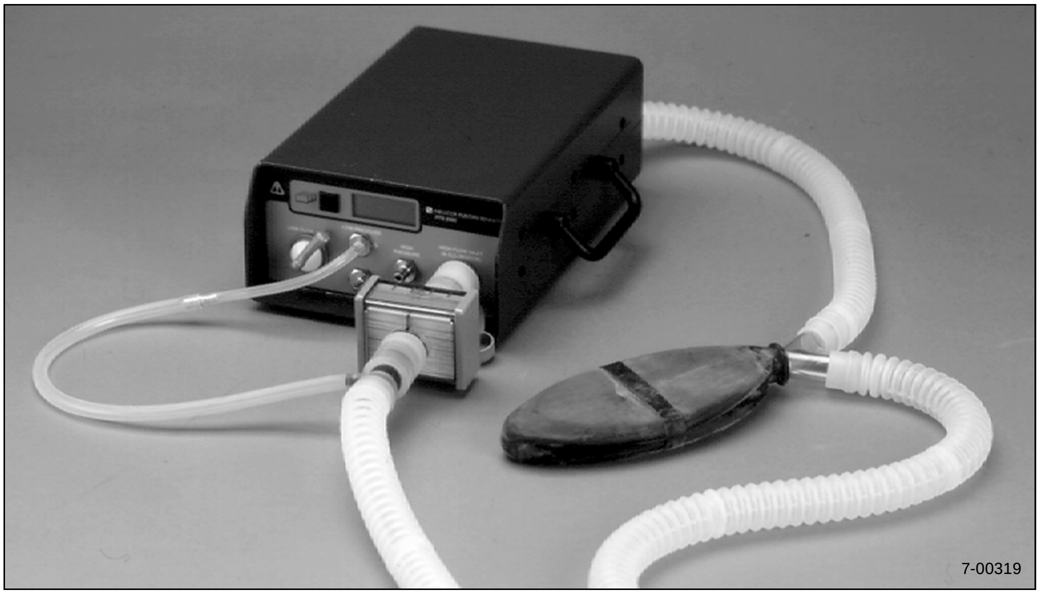


Figure 5-3. *PTS 2000* Setup for Test 5

1. When using the *PTS 2000*, set up the ventilator for test as shown in Figure 5-3:

NOTE:

Connect the *PTS 2000* with the inspiration limb of the patient tubing circuit. To ensure accurate volume measurement, place the patient wye and test lung some distance from the exhaust port of the *PTS 2000* . After installing the *PTS 2000* in the patient tubing circuit, run the SST to ensure that there are no leaks and accurately determine compliance compensation. Choose **HME** when the ventilator prompts you for the humidifier type.

NOTE:

Follow the *PTS 2000 User s Manual* instructions for setting up the unit with your computer. Set the *PTS 2000* for REMOTE OPERATION.

NOTE:

When using *PTS 2000 Breathlab* software to measure volume readings, select the *Volume (1 breath)* screen. Use the following settings: Units of measure in **mL**. Mode **ATP** threshold of **10 lpm**. Select multi and activate the arrow button to begin gathering data on each breath.

Measure PEEP in the *Low Pressure screen*. Measure oxygen percentage in the *% Oxygen* screen or the *All parameters* screen.

2. Change the settings shown in bold.

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_20
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**30 breaths/min**
TIDAL VOLUME	**100 mL**
PEAK FLOW	**30 L/m**
PLATEAU	0 s
PEEP/CPAP	**3 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21 %

3. Wait until the ventilator delivers at least 10 breaths.
4. Make the following measurements, and VERIFY that the readings are as listed below. **See Section 5.7 O, P, Q**.

NOTE:

When making PEEP measurements at high rates the readings will fluctuate, making it difficult to take an accurate reading. To eliminate this difficulty, PEEP can be measured with the rate turned down to 3 breaths/min.

Measure the following	**Acceptable range**
Tidal volume	80 to 120 mL
Respiratory rate	29 to 31 breaths/min
PEEP	0.95 to 5.05 cmH_2O

5. Change the settings shown in **bold**.

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_20
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**20 breaths/min**
TIDAL VOLUME	**600 mL**
PEAK FLOW	**60 L/m**
PLATEAU	0 s
PEEP/CPAP	**15 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21 %

6. Make the following measurements, and VERIFY that the readings are as listed below. **See Section 5.7 O, P, Q**.

Measure the following	Acceptable range
Tidal volume	530 to 670 mL
Respiratory rate	19 to 21 breaths/min
PEEP	12.56 to 17.44 cmH_2O

7. Change the ventilator setting shown in **bold**.

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	0 mL
HIGH PRESSURE	90 cmH_20
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**10 breaths/min**
TIDAL VOLUME	**1000 mL**
PEAK FLOW	**80 L/m**
PLATEAU	0 s
PEEP/CPAP	**20 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	21 %

8. Make the following measurements, and VERIFY that the readings are as listed below. **See Section 5.7 O, P, Q**.

Measure the following	**Acceptable range**
Tidal volume	890 to 1110 mL
Respiratory rate	9 to 11 breaths/min
PEEP	17.39 to 22.61 cmH_2O

5.6.7 Extended self-test (EST) (Test 6)

Warning

- Before running EST, you must disconnect the ventilator from the patient. Running EST while the ventilator is connected to the patient can injure the patient.
- Do not use or override a ventilator that completes EST with a fault status without first verifying its operational readiness by an independent means and determining that a patient will not be placed at risk.
- Nellcor Puritan Bennett urges medical departments to review the implications of using a ventilator that completed EST with a fault status. Nellcor Puritan Bennett recommends establishing a medical department protocol that defines the conditions under which ventilator usage is acceptable.

1. You can to run EST from the main menu or the service menu.

   To run EST from the Main menu:

   a. Turn on the ventilator. If ventilation has already begun since the ventilator was turned on, turn off the ventilator and turn it back on without starting ventilation.
   b. Press MENU, turn the knob to select **Self test**, then press ACCEPT. Turn the knob to select **Extended self test**.

   To run EST from the service menu:

   a. Press MENU while simultaneously powering on ventilator. Do not release MENU until prompted by message window.
   b. After POST is completed, press MENU again, turn knob to select **A. Service menu**, then press ACCEPT.
   c. Turn knob to select **EST**
2. Respond to prompts, referring to Section 3.
3. VERIFY that EST passes. **See Section 5.7 H.**
4. Connect test lung to patient wye, if not already connected.

5.6.8 Oxygen accuracy test (Test 7) using the RT-200

NOTE:
Verify that the oxygen analyzer is calibrated before running this test.

The oxygen accuracy test verifies the accuracy of the oxygen delivery system and confirms its monitoring ability.

1. Tee oxygen analyzer into inspiratory limb at inspiratory filter outlet.

2. Change the ventilator settings shown in **bold**.

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	**5 mL**
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**50 breaths/min**
TIDAL VOLUME	**100 mL**
PEAK FLOW	**30 L/min**
PLATEAU	0 s
PEEP/CPAP	**0 cmH_2O**
TRIGGER SENSITIVITY	20 L/min
% O_2	**30**

3. Wait 3 minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 27 and 33% and that no oxygen alarms activate (if applicable). **See Section 5.7 R.**

4. Change the ventilator settings shown in **bold.**

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**20 breaths/min**
TIDAL VOLUME	**600 mL**
PEAK FLOW	**60 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**60**

5. Wait $1^1/_2$ minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 57 and 63%, and that no oxygen alarms activate (if applicable). **See Section 5.7 R.**

6. Change the ventilator settings shown in **bold.**

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**10 breaths/min**
TIDAL VOLUME	**1000 mL**
PEAK FLOW	**80 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**100**

7. Wait $1^1/_2$ minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 97 and 100%, and that no oxygen alarms activate (if applicable). **See Section 5.7 R.**

8. Remove oxygen analyzer and tee, and return inspiratory limb to previous configuration.

5.6.9 Oxygen accuracy test (Test 7) using the *PTS 2000*

NOTE:

Verify that the oxygen analyzer is calibrated before running this test.

The oxygen accuracy test verifies the accuracy of the oxygen delivery system and confirms its monitoring ability.

1. Change the ventilator settings shown in **bold**.

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**50 breaths/min**
TIDAL VOLUME	**100 mL**
PEAK FLOW	**30 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**30**

2. Wait 3 minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 27 and 33% and that no oxygen alarms activate (if applicable). **See Section 5.7 R.**

3. Change the ventilator settings shown in **bold.**

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**20 breaths/min**
TIDAL VOLUME	**600 mL**
PEAK FLOW	**60 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**60**

4. Wait $1^1/_2$ minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 57 and 63%, and that no oxygen alarms activate (if applicable). **See Section 5.7 R.**

5. Change the ventilator settings shown in **bold.**

Control	**Setting**
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	90 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**10 breaths/min**
TIDAL VOLUME	**1000 mL**
PEAK FLOW	**80 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**100**

6. Wait $1^1/_2$ minutes for oxygen analyzer reading to stabilize. VERIFY that oxygen analyzer reads between 97 and 100%, and that no oxygen alarms activate (if applicable).

5.6.10 High pressure alarm test (Test 8) using the RT-200

The high pressure alarm test verifies that ventilator breathing circuit pressure is limited within specifications.

1. Change the ventilator settings shown in **bold.**

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	**15 cmH_2O**
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**6 breaths/min**
TIDAL VOLUME	**1500 mL**
PEAK FLOW	**15 L/min**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**21**

2. Set pressure measurement device to read in peak/continuous mode.
3. VERIFY that pressure readings displayed on ventilator's PRESSURE bar graph, PEAK PRESSURE display, and external pressure measurement device are all between 14.1 and 15.9 cmH_2O. **See Section 5.7 S.**
4. Remove test equipment, and return ventilator to original configuration.

5.6.11 High pressure alarm test (Test 8) using the *PTS 2000*

The high pressure alarm test verifies the ventilator breathing circuit pressure is limited within specification.

1. Change the ventilator settings shown in **bold**.

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	**15 cmH_20**
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	**6 breaths/min**
TIDAL VOLUME	**1500 mL**
PEAK FLOW	**15 L/m**
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	**21 %**

2. Set *Breathlab* software to measure to low pressure. Let the ventilator breathe at least 2 breaths.
3. VERIFY the pressure readings displayed on the ventilator's PRESSURE bar graph, PEAK PRESSURE display, and the MAX pressure reading in *Breathlab's* software are all between 14.1 and 15.9 cmH_2O.
4. Remove test equipment, and return ventilator to original configuration.

5.6.12 Safety valve test (Test 9)

The safety valve test verifies that the safety valve opens when the exhalation valve fails.

1. Verify that ventilator settings are as follows.

Control	Setting
HIGH RATE	100 breaths/min
HIGH TIDAL VOLUME	1500 mL
LOW INSP PRESSURE	3 cmH_2O
LOW TIDAL VOLUME	5 mL
HIGH PRESSURE	15 cmH_2O
LOW MINUTE VOLUME	0 L
Mode	A/C, VCV (SQUARE flow waveform for software revision J or later)
RESPIRATORY RATE	6 breaths/min
TIDAL VOLUME	1500 mL
PEAK FLOW	15 L/min
PLATEAU	0 s
PEEP/CPAP	0 cmH_2O
TRIGGER SENSITIVITY	20 L/min
% O_2	21

1. Block exhalation valve exhaust port with no. 3 stopper.
2. Block patient wye with no. 2 stopper.
3. VERIFY that safety valve opens when an inspiration is delivered. **See Section 5.7 T.**

NOTE:

For ventilators with software revision E or later, the safety valve opens then closes again when it enters occlusion cycling mode. (On ventilators with earlier software than revision E, the safety valve opens and remains open until you press ALARM RESET.)

---

4. Remove stoppers.
5. Remove test equipment, and return ventilator to original configuration.

5.7 Troubleshooting

NOTE:

Use the service menu *Sensor data* function (described in Section 4.2.1) to help confirm the failure of suspect components.

Use this troubleshooting information in conjunction with the performance verification tests.

These procedures are sequenced to correct the most probable malfunction or to present the most efficient corrective action first. The proposed fixes listed, however, may not always correct the particular problem.

Do not overlook problems found after this inspection, and perform the necessary repairs. The results of future tests could be affected.

NOTE:

This troubleshooting information assumes EST has passed. Use Section 3 to diagnose EST failures.

A Ground line resistance (including power cord) >0.2 Ω

a. Disconnect ventilator from electrical safety analyzer.

b. Verify that correct power cord (with grounding plug) is being used and that there is no visible damage to power cord. Check continuity of power cord. Replace power cord, as required.

c. Verify that ground wire from line filter to power tray is secure.

d. Replace power cord.

e. Replace line filter.

B POST failed

See Section 6.

C Leakage current >300 μA (100/115 V units) or >500 μA (220/240 V units)

a. Disconnect ventilator from electrical safety analyzer.

b. Verify that correct power cord and line filter are being used and that there is no visible damage to power cord. Verify that power cord has no shorts. Replace power cord, if indicated.

c. Verify secure harness connections of power input components (line filter, circuit breaker, power switch, and power supply terminal block).

d. Replace power cord.

e. Replace power input components as necessary.

D Main fan not operating properly

a. Verify correct voltage to fan (+23 to +25 V when ventilator is powered by ac). If inadequate or no voltage, troubleshoot from fan back toward power input components.

b. Verify that main fan/ventilator head harness connection is secure.

c. Replace main fan.

d. Replace pressure solenoid PCB.

E Rotary encoder test failed

a. Verify that rotary encoder cable connections are secure.

b. Verify that ventilator head/UI cable connections are secure.

c. Replace rotary encoder.

d. Replace controller PCB.

F External battery test failed

a. Verify that there is no visible damage to battery harness and connector.

b. Check external battery fuse. Replace as necessary.

c. Using *Sensor data* function in service menu, check external battery voltage. If voltage is low, charge battery and repeat test step.

d. Replace external battery.

e. Check continuity of external battery harness. Replace harness, as required.

f. Replace BBU PCB.

G Internal battery test failed

a. Verify that there is no visible damage to battery harness and connector.

b. Verify battery level. If charge is low, repeat test (Section 5.6.3.2: if battery is not charging, through step 4; if battery *is* charging, through step 6).

c. Replace internal battery.

d. Check continuity of internal battery harness. Replace harness, as required.

e. Replace BBU PCB.

H EST failed

See Section 3.

I +24 V out of range

Disconnect main ventilator head harness from pressure solenoid PCB. Disconnect BBU PCB/ventilator head harness from controller PCB, and verify that voltage between pins 36 (24V) and 31 (GND) of BBU PCB/ventilator head harness is between +23 and +25 V. If voltage is in range, replace pressure solenoid or controller PCB. If voltage is low or not present, verify +24 V output from power supply at power output terminal block. If this voltage is in range, replace BBU PCB. If this voltage is low or not present, replace power supply.

J -15 V out of range

Replace pressure solenoid PCB.

K +5V out of range

a. Replace pressure solenoid PCB.

b. Replace controller PCB.

L +1.2V out of range

Replace pressure solenoid PCB.

M UI-5V out of range

Replace UI display PCB.

N 15V out of range

Replace pressure solenoid PCB.

O Tidal volume out of range

a. Verify that test equipment used is calibrated and working correctly.

b. Verify that ventilator settings are correct.

c. Verify that all tubing connections are secure, check tubing and test lung for leaks, and verify that setup is correct.

d. Rerun SST.

e. Using *Sensor data* function in service menu, verify that atmospheric pressure (Pa) is correct. If atmospheric pressure transducer reading is incorrect, replace pressure transducer PCB.

f. Rerun EST, making sure Piston leak test passes. If test fails, replace cylinder inlet check valve.

P Respiratory rate out of range

a. Verify that test equipment used is calibrated and working correctly.

b. Verify that ventilator settings are correct, particularly that TRIGGER SENSITIVITY is set to 10 L/min.

c. Rerun SST.

Q PEEP reading out of range

a. Verify that test equipment used is calibrated and working correctly.

b. Verify that ventilator settings are correct.

c. Verify that all tubing connections are secure, and check tubing and test lung for leaks.

d. Rerun SST.

e. Recalibrate PEEP pump.

f. Replace PEEP pump inlet filter.

g. Replace PEEP pump.

R Oxygen accuracy test failed

NOTE:

Verify that the oxygen analyzer is calibrated and working correctly.

---

a. Make sure oxygen source pressure is between 40 and 90 psi (275 to 620 kPa).

b. Verify that ventilator settings are correct.

c. Verify that all tubing connections are secure, and check tubing and test lung for leaks.

d. Perform oxygen sensor calibration check.

e. Replace oxygen sensor.

f. Recalibrate oxygen regulator pressure sensor.

g. Replace oxygen regulator assembly.

h. Replace pressure solenoid PCB.

S High pressure alarm test failed

a. Verify that ventilator settings are correct.

b. Verify that all tubing connections are secure, and check tubing and test lung for leaks.

c. Verify that tubing between exhalation assembly, autozero solenoid, and pressure transducer is securely connected.

d. Replace pressure solenoid PCB.

e. Replace controller PCB.

T Safety valve test failed

a. Verify that safety valve/ventilator head harness connection is secure.

b. Check safety valve resistance (10.5 to 14 Ω). Replace safety valve, as required.

c. Replace safety valve.

d. Replace pressure solenoid PCB.

Diagnostic codes

Use this section to interpret diagnostic codes, which are in the alert and test logs. The alert log contains codes generated by ongoing checks during ventilation. The test log contains codes generated by the power-on self-test (POST), the short self-test (SST), the extended self-test (EST), and calibrations.

The logs also contain other information that can be useful when troubleshooting the ventilator. Section 4 describes how to access and interpret these logs.

6.1 How to use this section

If the ventilator has declared a VENT INOP condition, you must repair the ventilator and then run and pass EST before ventilation can resume. To do so, first cycle power to the ventilator. The ventilator will now let you access a limited set of service menu functions only (see Section 4). Use the *EST* function to run the extended self-test. The results of the EST run, the contents of the test and/or alert logs, and other service menu functions will help you determine what to repair. (The most recently detected error (the error that triggered the VENT INOP condition) is stored in the test and/or alert log.)

Also review any other codes, all of which may help you more accurately pinpoint the failed component. Be aware, however, that some codes may represent transient failures, which may not recur. For some codes, particularly software and some hardware failures, the ventilator tries to reset itself immediately after detection of the error. The associated code will remain in memory even though the ventilator may be successfully reset. Check the time and date stamp associated with the code to determine its relevance.

If the ventilator has not declared a VENT INOP condition, and you are checking the log for other reasons, bear in mind that codes may represent transient failures that may not require repair or they may represent software or hardware errors that caused the ventilator to successfully reset itself. If the error condition causes the ventilator to declare a VENT INOP condition, then that error must be dealt with as described above.

6.2 About software errors

Many of the codes in this section represent “software errors.” The software continually makes reasonableness and other data checks. If any of these checks fails, a software error is logged and the ventilator is reset, which causes POST to run. If POST does not pass, the ventilator issues up to two more system resets, waiting for POST to pass. If POST is still not passed, the ventilator declares a VENT INOP condition. As a result, the patient can breathe through the opened safety valve. Similarly, if three or more software errors are detected within 24 operating hours, the ventilator declares a VENT INOP condition.

Often, a software error is a transient failure, which is not expected to recur. When the system is reset, POST passes, and ventilation continues. If a software error recurs or if multiple software errors occur, the problem requires corrective action. Contact your regional Nellcor Puritan Bennett Technical Support.

6.3 About ventilator status (13000 series) codes

Codes in the 13000 series (ventilator status codes) provide information on:

- What the ventilator was doing at the time a ventilator reset occurred
- The overall pass/fail status SST and EST

Because a ventilator reset can be triggered by detection of an unexpected condition, a post-reset status code is often, but not always, accompanied by a code representing that triggering condition. If another code was recorded in the test log immediately before the reset code was recorded, troubleshoot the ventilator from that accompanying code. If an accompanying code was not recorded, particularly if the reset recurs, the problem requires corrective action. Contact your regional Nellcor Puritan Bennett Technical Support.

The SST and EST pass/fail status codes are for information only and do not in themselves require corrective action.

6.4 List of codes

Refer to Table 6-1 to interpret the codes in the alert and test logs. The first column lists, in numeric order, the codes. The second column lists the part of software that was running when the error was detected. The third column identifies possible causes. The fourth column suggests how to correct the condition. These procedures are sequenced to correct the most probable malfunction or to present the most efficient corrective action first. The proposed fixes listed, however, may not always correct the particular problem.

NOTE:

- Use the service menu *Sensor data* function to help confirm the failure of suspect components.
- If the listed actions do not correct an electronic problem, try replacing the controller PCB. Although replacing the controller PCB may not be listed as a corrective action, many of the ventilator's electronic circuits ultimately are controlled by that PCB.

Table 6-1: Diagnostic codes

Code	Software	Possible cause	Corrective action
1000-1177	UI application	Software error	See Section 6.2.
1178	UI application	The unit was shut down after low power was detected. The ac supply was lost and all batteries in unit are exhausted.	1. Restore ac power, if possible. 2. Replace batteries.
1179-1xxx	UI application	Software error	See Section 6.2.
2000-2xxx	UI driver	Software error	See Section 6.2.
3000-3xxx	BDMC application	Software error	See Section 6.2.
4000-4xxx	BDMC driver	Software error	See Section 6.2.
5000-5012	Interprocessor communication	Software error	See Section 6.2.
5013	Interprocessor communication	Microcontroller or other hardware failure	Replace controller PCB.
5014	Interprocessor communication	Software error Microcontroller failure	See Section 6.2. Replace controller PCB.
5015	Interprocessor communication	Microcontroller or other hardware failure	Replace controller PCB.
5016-5xxx	Interprocessor communication	Software error	See Section 6.2.
6001	Built in ongoing tests (BIOT) (technical alert -- LOSS OF POWER)	The ac supply was lost and the batteries are so low that all power may be lost. The unit will shut down in 5 minutes.	1. Restore ac power, if possible. 2. Check battery connections. 3. Replace batteries (internal and external, if installed) as necessary. 4. Replace BBU PCB.
		NOTE: Actual battery backup time remaining depends on battery condition and ventilator settings.	
6002	BIOT (technical alert -- MOTOR OVER TEMP)	Motor temperature too high	1. Clean or replace main fan filter. 2. Check for proper operation of main fan. 3. Replace motor/encoder. 4. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6003	BIOT (technical alert -- CONTINUOUS HI PRES)	HIGH PRESSURE alarm is active, but circuit pressure has not dropped below HIGH PRESSURE setting. This points to a failure to open the exhalation valve.	1. Check patient; provide alternate ventilation. 2. Make sure EXHAUST port is not blocked. 3. Replace exhalation solenoid. 4. Replace pressure solenoid PCB. 5. Replace exhalation valve.
6004	BIOT (technical alert -- FAN FAILED ALERT)	Fan filter occluded or fan not operational	1. Make sure main fan is operating. 2. Make sure room temperature is not too low. Make sure that ventilator has warmed up and attained a steady-state temperature (*after* removing the ventilator from its packaging). 3. Make sure ventilator lid is securely closed and that the lid gasket is not torn. 4. Make sure vents in unit are not blocked. 5. Replace fan filter, as necessary. 6. Check that main fan/ventilator head harness connection is secure. 7. Replace main fan. 8. Replace air flow thermistor assembly.
		NOTE: Error code 6004 can be caused by a fan that draws no current *or* by insufficient air flow into the ventilator and across the air flow thermistor. If the fan is operating, the cause of this error code is insufficient air flow into the ventilator.	
6006	BIOT (technical alert -- BAT NOT CHARGING)	Battery voltage has not increased during past hour	1. Check connections and charge of batteries. 2. Replace applicable battery. 3. Replace BBU PCB.
6007	BIOT (technical alert -- SPEAKER FAILED)	Main alarm speaker failed and backup alarm sounds	1. Check wiring to speaker. 2. Replace speaker. 3. Replace pressure solenoid PCB.
6008	BIOT (technical alert -- KEYBOARD FAILED)	A key was held down longer than expected	1. Verify that keyboard cable is securely connected to UI display PCB. 2. Replace keyboard. 3. Replace controller PCB. 4. Replace UI display PCB.
		NOTE: Holding down any key other than MENU during POST causes error code 6008.	

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6009	BIOT (technical alert -- LOW SYS TEMP ALERT)	Temperature inside ventilator enclosure too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tbox attained a steady state. 2. Replace pressure solenoid PCB.
6010	BIOT (technical alert -- HI SYS TEMP ALERT)	Temperature inside ventilator enclosure too high	1. Make sure room temperature is not too high. 2. Make sure vents in unit are not blocked. 3. Make sure main fan is operating properly. Clean or replace fan filter, as necessary. 4. Replace pressure solenoid PCB.
6011	BIOT (technical alert -- EXH CCT LOW TEMP)	Exhalation limb temperature too low	1. Check connections of exhalation heater and thermistor assemblies. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
		NOTE: Be aware that spirometry may be affected (monitored values may be higher than actual).	
6012	BIOT (technical alert -- EXH CCT HI TEMP)	Exhalation limb temperature too high	1. Check connections of exhalation heater and thermistor assemblies. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
		NOTE: Be aware that spirometry may be affected (monitored values may be higher than actual).	
6013	BIOT (technical alert -- FLO SENSOR LO TEMP)	Temperature at exhalation flow sensor pressure transducer too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Replace pressure solenoid PCB.
6014	BIOT (technical alert -- FLO SENSOR HI TEMP)	Temperature at exhalation flow sensor pressure transducer too high	1. Make sure room temperature is not too high. 2. Replace pressure solenoid PCB.
6015	BIOT (technical alert -- LOW BBU TEMP ALERT)	Temperature measured on BBU PCB too low	1. Replace BBU PCB. 2. Replace power supply.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6016	BIOT (technical alert -- HI BBU TEMP ALERT)	Temperature measured on BBU PCB too high	1. Make sure power supply fan harness is securely connected. 2. Replace power supply fan. 3. Replace BBU PCB.
6017	BIOT (technical alert -- DELIV GAS LOW TEMP)	Inspiration manifold temperature too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tdel attained a steady state. 2. Check wiring from thermistor to pressure solenoid PCB. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
6018	BIOT (technical alert -- DELIV GAS HI TEMP)	Inspiration manifold temperature too high	1. Make sure room temperature is not too high. 2. Check wiring from thermistor to pressure solenoid PCB. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
6019	BIOT (technical alert -- SERVICE XDUCER)	Exhalation, cylinder, or flow sensor pressure transducer drift	1. Make sure that ventilator has warmed up sufficiently and is at a steady-state temperature. 2. Replace pressure solenoid PCB.
6020	BIOT (technical alert -- BATTERY FUSE FAILED)	Open circuit detected in internal battery output	1. Make sure internal battery was not removed during operation. 2. Replace internal battery.
6021	BIOT (technical alert -- AIR INTAKE BLOCKED)	Ventilator has detected above-normal resistance at air intake filter during POST after power switched on.	1. Check patient. 2. Check for visible occlusions (for example, a curtain, clothing, or furniture blocking air intake). 3. Replace air intake filter.
6022	BIOT (technical alert -- REPLACE O2 SENSOR)	Oxygen sensor missing or reading out of range	1. Make sure an oxygen sensor is installed and securely connected to ventilator head harness. 2. Perform FIO_2 sensor calibration check. 3. Replace oxygen sensor.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6023	BIOT (technical alert -- LOW INSP PRESSURE)	Exhalation pressure transducer reading (P_e) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Check for ventilator breathing circuit disconnect. 3. Make sure air intake filter is not occluded. 4. Check reasonableness of P_e reading using *Sensor data* function while ventilation is occurring. Perform a P_e/P_{cyl} gain equalization as required. 5. Replace pressure solenoid PCB.
6024	BIOT (technical alert -- LOW INSP PRESSURE)	Inspiration pressure transducer reading (P_i) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Check for ventilator breathing circuit disconnect. 3. Make sure air intake filter is not occluded. 4. Check reasonableness of P_i and P_a readings using *Sensor data* function while ventilation is occurring. Perform a P_e/P_{cyl} gain equalization as required. Replace pressure solenoid PCB.
6025	BIOT (technical alert -- LOW INSP PRESSURE)	Cylinder pressure transducer reading (P_{cyl}) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Check for ventilator breathing circuit disconnect. 3. Make sure air intake filter is not occluded. 4. Check reasonableness of P_{cyl} reading using *Sensor data* function while ventilation is occurring. Perform a $P_e/_{cyl}$ gain equalization as required. 5. Replace pressure solenoid PCB.
6026	BIOT (technical alert -- CONTACT SERVICE)	Flow sensor offset has changed by an unexpectedly large value	1. Verify that tubes between flow sensor and pressure transducer are securely connected. 2. Make sure EXHAUST port is not blocked. 3. Check flow sensor calibration constants. 4. Replace flow sensor. 5. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6027	BIOT (technical alert -- CONTACT SERVICE)	Safety valve should be closed, but measured current is too low	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
6028	BIOT (technical alert -- CONTACT SERVICE)	Safety valve should be closed, but measured current is too high	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
6029	BIOT (technical alert -- CONTACT SERVICE)	No current to ALARM light when it should be on	1. Replace UI display PCB. 2. Replace controller PCB.
6030	BIOT (technical alert -- CONTACT SERVICE)	There is current to ALARM light when it should be off	1. Replace UI display PCB. 2. Replace controller PCB.
6031	BIOT (technical alert -- CONTACT SERVICE)	No current to CAUTION light when it should be on	1. Replace UI display PCB. 2. Replace controller PCB.
6032	BIOT (technical alert -- CONTACT SERVICE)	There is current to CAUTION light when it should be off	1. Replace UI display PCB. 2. Replace controller PCB.
6033	BIOT (technical alert -- CONTACT SERVICE)	Battery current low	1. Replace appropriate battery. 2. Replace BBU PCB. 3. Replace controller PCB.
6034	BIOT (technical alert -- CONTACT SERVICE)	Battery current high	1. Replace appropriate battery. 2. Replace BBU PCB. 3. Replace controller PCB.
6035	BIOT (technical alert -- CONTACT SERVICE)	PEEP pump current low	1. Verify that resistance of PEEP pump is between 12 and 15 Ω measured when pump is at ambient temperature. If it is not replace pump. 2. Check continuity of wiring to PEEP pump. Replace harness if necessary. 3. Replace pressure solenoid PCB. 4. Replace BBU PCB. 5. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6036	BIOT (technical alert -- CONTACT SERVICE)	PEEP pump current high	1. Verify that resistance of PEEP pump is between 12 and 15 Ω measured when pump is at ambient temperature. If it is not replace pump. 2. Check continuity of wiring to PEEP pump. Replace harness if necessary. 3. Replace pressure solenoid PCB. 4. Replace BBU PCB. 5. Replace controller PCB.
6037	BIOT (technical alert -- AIR INTAKE ABSENT)	Air intake filter switch open.	1. Verify that air intake filter is installed and that it engages air intake filter switch. 2. Check that air intake filter switch/ ventilator head harness connection is secure. 3. Replace air intake filter. 4. Replace air intake filter switch. 5. Replace pressure solenoid PCB.
6038	BIOT (technical alert -- CONTACT SERVICE)	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
6039	POST (technical alert -- VALVES TEST FAILED)	Safety valve stuck closed during POST	1. Check state of safety valve during POST. If stuck closed, replace. 2. If safety valve open during POST, replace cylinder outlet check valve.
6040	Ongoing hardware checks	Nebulizer failed alert, power not being supplied to nebulizer.	1. Check cable connections between the communications panel and the nebulizer. 2. Replace the cable. 3. Check cable connections between the communications PCB and the controller PCB. 4. Replace the cable. 5. Replace communications PCB. 6. Replace the nebulizer.
6041	BIOT (technical alert -- PARTIAL OCCLUSION)	Partial occlusion in one limb of the breathing circuit.	1. Check patient. 2. Check limbs for blockages. 3. Check exhaust port for blockage. 4. Replace pressure solenoid PCB.
6042	BIOT (technical alert -- PCYL COMPARE ALLERT)	P_{cyl} transducer tube is incorrectly connected to P_i or P_e transducer.	1. Check tubing connections. 2. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
6043-6046	BIOT (technical alert -- CONTACT SERVICE)	BBU signal conflict: signals indicate both battery and AC power operation.	1. Verify AC power to the ventilator. 2. Verify battery voltage. 3. Check that connections between the BBU and controller PCBs are secure. 4. Replace BBU PCB. 5. Replace controller PCB.
7000	POST	Software error	See Section 6.2.
7001	POST	Software error	See Section 6.2.
7002	POST	Software error	See Section 6.2.
7003	POST	Microcontroller or other hardware failure	Replace controller PCB.
7004	POST	Microcontroller or other hardware failure	Replace controller PCB.
7005	POST	Microcontroller or other hardware failure	Replace controller PCB.
7006	POST	Microcontroller or other hardware failure	Replace controller PCB.
7007	POST	Motor/piston failure	1. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace BBU PCB/ventilator head harness. 6. Check mesh of pinion gear with rack. Remesh as necessary. 7. Replace optoswitches.
7008	POST	Motor/piston failure	1. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace BBU PCB/ventilator head harness. 6. Check mesh of pinion gear with rack. Remesh as necessary. 7. Replace optoswitches.
7009	POST	A VENT INOP condition was declared.	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7010	POST	Safety valve failure	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
7011	POST	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
7012	POST	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
7013	POST	Main alarm speaker failure	1. Check speaker resistance (6 to 8 Ω). 2. Check main ventilator head harness continuity. Replace harness, as required. 3. Replace speaker. 4. Replace pressure solenoid PCB.
7014	POST	Not Ventilating signal used in UI/BD communications is not in expected state.	1. Power off ventilator. Wait 15 seconds. Power on ventilator. 2. See Section 6.2. 3. Replace controller PCB.
7015	POST	Bus monitor error	Replace controller PCB.
7016	POST	UI microcontroller failure	Replace controller PCB.
7017	POST	Software error	See Section 6.2.
7018	POST	UI clock failure	Replace controller PCB.
7019	POST	BD POST failed	Replace controller PCB.
7020	POST	BD microcontroller failure	Replace controller PCB.
7021	POST	Software error	See Section 6.2.
7022	POST	Software error	See Section 6.2.
7023	POST	Software error	See Section 6.2.
7024	POST	Software error	See Section 6.2.
7025	POST	Software error	See Section 6.2.
7026	POST	Software error	See Section 6.2.
7027	POST	Software error	See Section 6.2.
7028	POST	Controller PCB and ventilator software versions incompatible	Install controller PCB version compatible with software version.
7029	POST	Controller PCB and ventilator software versions incompatible	1. Install ventilator software version compatible with PCB version. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7030	POST	Pressure solenoid PCB and ventilator software versions incompatible	Install pressure solenoid PCB version compatible with software version.
7031	POST	Pressure solenoid PCB and ventilator software versions incompatible	1. Install ventilator software version compatible with PCB version. 2. Replace pressure solenoid PCB.
7032	POST	BBU PCB and ventilator software versions incompatible	Install BBU PCB version compatible with software version.
7033	POST	BBU PCB and ventilator software versions incompatible	1. Install ventilator software version compatible with PCB version. 2. Replace BBU PCB.
7034	POST	Controller PCB +1.2 V reference (for A/D converter) too low	Replace controller PCB.
7035	POST	Controller PCB +1.2 V reference (for A/D converter) too high	Replace controller PCB.
7036	POST	Controller PCB +5 V too low	Replace controller PCB.
7037	POST	Controller PCB +5 V too high	Replace controller PCB.
7038	POST	Controller PCB +2.5 V reference too low	Replace controller PCB.
7039	POST	Controller PCB +2.5 V reference too high	Replace controller PCB.
7040	POST	Cylinder pressure too low	Replace pressure solenoid PCB.
7041	POST	Cylinder pressure too high	Replace pressure solenoid PCB.
7042	POST	Exhaled flow too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace pressure solenoid PCB.
7043	POST	Exhaled flow too high	1. Make sure room temperature is not too high. 2. Replace pressure solenoid PCB.
7044	POST	Current to PEEP pump too low	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
7045	POST	Current to PEEP pump too high	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
7046	POST	Current to safety valve too low	Replace pressure solenoid PCB.
7047	POST	Current to safety valve too high	Replace pressure solenoid PCB.
7048	POST	Exhalation pressure too low	Replace pressure solenoid PCB.
7049	POST	Exhalation pressure too high	Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7050	POST	Absolute inspiration pressure too low	Replace pressure solenoid PCB.
7051	POST	Absolute inspiration pressure too high	Replace pressure solenoid PCB.
7052	POST	Piston velocity too high	1. Replace motor/encoder. 2. Replace pressure solenoid PCB. 3. Replace controller PCB.
7053	POST	Software error	See Section 6.2.
7054	POST	Software error	See Section 6.2.
7055	POST	A/D converter error	Replace controller PCB.
7056	POST	Memory error	Replace controller PCB.
7057	POST	Memory error	Replace controller PCB.
7058	POST	Memory error	Replace controller PCB.
7059	POST	Bus monitor error	Replace controller PCB.
7060	POST	Bus monitor error	Replace controller PCB.
7061	POST	Bus monitor error	Replace controller PCB.
7062	POST	Bus monitor error	Replace controller PCB.
7063	POST	A VENT INOP condition was declared.	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7064	POST	Safety valve failure	1. Replace safety valve. 2. Replace pressure solenoid PCB.
7065	POST	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
7066	POST	CAUTION light failure	1. Replace UI display PCB. 2. Replace controller PCB.
7067	POST	Main fan failure	1. Make sure main fan is operating. 2. Make sure room temperature is not too low. Make sure that ventilator has warmed up and attained a steady-state temperature. 3. Make sure ventilator lid is closed. 4. Make sure vents in unit are not blocked. 5. Clean or replace fan filter, as necessary. 6. Check that main fan/ventilator head harness connection is secure. 7. Replace main fan. 8. Replace air flow thermistor assembly.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7068	POST	Not Ventilating signal used in UI/ BD communications is not in expected state.	1. Power off ventilator. Wait 15 seconds. Power on ventilator. 2. See Section 6.2. 3. Replace controller PCB.
7069	POST	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
7070	POST	Main alarm speaker failure	1. Check wiring to speaker. 2. Replace speaker. 3. Replace pressure solenoid PCB.
7071	POST	An option panel erroneously appears to be installed.	1. Make sure option connector is disconnected. 2. Replace controller PCB.
7072	POST	An option PCB erroneously appears to be installed.	1. Make sure option connector is disconnected. 2. Replace controller PCB.
7074	POST	BBU PCB/controller PCB or UI display PCB/LCD panel connection error	1. Check that BBU PCB/controller PCB cable connections are secure. 2. Check that UI display PCB/LCD panel connections are secure. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace UI display PCB.
7075	POST	Ventilator head connection error	1. Check that ventilator head harness/ controller PCB connection is secure. 2. Replace controller PCB.
7076	POST	Rotary encoder failure or other hardware failure	1. Replace rotary encoder. 2. Replace UI display PCB. 3. Replace controller PCB.
7077	POST	Hardware failure	Replace controller PCB.
7078	POST	Hardware failure	Replace controller PCB.
7079	POST	Controller PCB and ventilator software versions incompatible	Install controller PCB version compatible with software version.
7080	POST	Controller PCB and ventilator software versions incompatible	1. Install ventilator software version compatible with PCB version. 2. Replace controller PCB.
7081	POST	Pressure solenoid PCB and ventilator software versions incompatible	Install pressure solenoid PCB version compatible with software version.
7082	POST	Pressure solenoid PCB and ventilator software versions incompatible	1. Install ventilator software version compatible with PCB version. 2. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7083	POST	BBU PCB and ventilator software versions incompatible	Install BBU PCB version compatible with software version.
7084	POST	BBU PCB revision too high for ventilator software	1. Install ventilator software version compatible with PCB version. 2. Replace BBU PCB.
7085	POST	UI display PCB +24 V too low	1. Replace UI display PCB. 2. Replace controller PCB.
7086	POST	UI display PCB +24 V too high	1. Replace UI display PCB. 2. Replace controller PCB.
7087	POST	UI display PCB +5 V too low	1. Replace UI display PCB. 2. Replace controller PCB.
7088	POST	UI display PCB +5 V too high	1. Replace UI display PCB. 2. Replace controller PCB.
7089	POST	Internal battery voltage too low	1. Replace internal battery. 2. Replace BBU PCB.
7090	POST	External battery voltage too low	1. Replace external battery. 2. Replace BBU PCB.
7091	POST	+24 V supply voltage too low	1. Check ac/battery connections. 2. Replace power supply. 3. Replace BBU PCB.
7092	POST	+24 V supply voltage too high	1. Check ac/battery connections. 2. Replace power supply. 3. Replace BBU PCB.
7093	POST	Battery current too low while charging	1. Replace applicable battery. 2. Replace BBU PCB.
7094	POST	Battery current too high while charging	1. Replace applicable battery. 2. Replace BBU PCB.
7095	POST	Battery current too low while discharging	1. Replace applicable battery. 2. Replace BBU PCB.
7096	POST	Battery current too high while discharging	1. Replace applicable battery. 2. Replace BBU PCB.
7097	POST	Controller PCB +1.2 V reference too low	Replace controller PCB.
7098	POST	Controller PCB +1.2 V reference too high	Replace controller PCB.
7099	POST	Controller PCB +1.2 V reference too low	Replace controller PCB.
7100	POST	Controller PCB +1.2 V reference too high	Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7101	POST	Pressure solenoid PCB +15 V too low	Replace pressure solenoid PCB.
7102	POST	Pressure solenoid PCB +15 V too high	Replace pressure solenoid PCB.
7103	POST	Pressure solenoid PCB -15 V too low	Replace pressure solenoid PCB.
7104	POST	Pressure solenoid PCB -15 V too high	Replace pressure solenoid PCB.
7105	POST	BBU PCB +15 V too low	Replace BBU PCB.
7106	POST	BBU PCB +15 V too low	Replace BBU PCB.
7107	POST	BBU PCB +5 V too low	Replace BBU PCB.
7108	POST	BBU PCB +5 V too high	Replace BBU PCB.
7109	POST	Temperature measured on BBU PCB too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up. 2. Replace BBU PCB. 3. Replace power supply.
7110	POST	Temperature measured on BBU PCB too high	1. Make sure room temperature is not too high. 2. Make sure power supply fan harness is securely connected. 3. Replace power supply fan. 4. Replace BBU PCB.
7111	POST	Controller PCB +2.5 V reference too low	Replace controller PCB.
7112	POST	Controller PCB +2.5 V reference too high	Replace controller PCB.
7113	POST	Controller PCB +12 V reference too high	Replace controller PCB.
7114	POST	Controller PCB +12 V reference too low	Replace controller PCB.
7115	POST	Ventilator internal temperature too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tbox attained a steady state. 2. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7116	POST	Ventilator internal temperature too high	1. Make sure room temperature is not too high. 2. Make sure vents in unit are not blocked. 3. Make sure main fan is operating properly. Clean or replace fan filter, as necessary. 4. Replace pressure solenoid PCB.
7117	POST	Temperature at exhalation flow sensor pressure transducer too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Replace pressure solenoid PCB.
7118	POST	Temperature at exhalation flow sensor pressure transducer too high	1. Make sure room temperature is not too high. 2. Replace pressure solenoid PCB.
7119	POST	Exhalation limb temperature too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled gas attained a steady-state temperature. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
7120	POST	Exhalation limb temperature too high	1. Make sure room temperature is not too high. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
7121	POST	Inspiration manifold temperature too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tdel attained a steady state. 2. Check that thermistor/main ventilator head harness connection is secure. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
7122	POST	Inspiration manifold temperature too high	1. Make sure room temperature is not too high. 2. Check that thermistor/main ventilator head harness connection is secure. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
7123	POST	Inspiration pressure too low	1. Verify that tubing between inspiration manifold and pressure transducer is securely connected. 2. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7124	POST	Inspiration pressure too high	1. Verify that tubing between inspiration manifold and pressure transducer is securely connected. 2. Replace pressure solenoid PCB.
7125	POST	Exhalation pressure too low	1. Verify that tubing between exhalation assembly, autozero solenoid, and pressure transducer is securely connected. 2. Replace pressure solenoid PCB.
7126	POST	Exhalation pressure too high	1. Verify that tubing between exhalation assembly, autozero solenoid, and pressure transducer is securely connected. 2. Replace pressure solenoid PCB.
7127	POST	Exhaled flow too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
7128	POST	Exhaled flow too high	1. Make sure exhaled gas temperature is stable. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
7129	POST	Oxygen supply pressure too low	1. Make sure oxygen source pressure is at least 40 psi. 2. Check for proper installation of oxygen regulator pressure transducer and connection of sensor to pressure solenoid PCB. 3. Calibrate oxygen regulator pressure transducer. 4. Replace oxygen regulator pressure transducer. 5. Replace pressure solenoid PCB. 6. Replace oxygen regulator assembly.
7130	POST	Oxygen supply pressure too high	1. Calibrate oxygen regulator pressure transducer. 2. Replace oxygen regulator pressure transducer. 3. Replace pressure solenoid PCB. 4. Replace oxygen regulator assembly.
7131	POST	Absolute inspiration pressure too low	Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7132	POST	Absolute inspiration pressure too high	Replace pressure solenoid PCB.
7133	POST	Oxygen percentage reading too low	1. Perform *FIO2 sensor calib* function, making sure room temperature is same as expected room temperature during use. 2. Replace oxygen sensor. 3. Replace pressure solenoid PCB.
7134	POST	Oxygen percentage reading too high	1. Perform *FIO2 sensor calib* function, making sure room temperature is same as expected room temperature during use. 2. Replace oxygen sensor. 3. Replace pressure solenoid PCB.
7135	POST	Current to PEEP pump too low	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
7136	POST	Current to PEEP pump too high	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
7137	POST	Low oxygen supply pressure	1. Make sure oxygen source pressure is at least 40 psi. 2. Check for proper installation of oxygen regulator pressure transducer and connection of sensor to pressure solenoid PCB. 3. Calibrate oxygen regulator pressure transducer. 4. Replace oxygen regulator pressure transducer. 5. Replace pressure solenoid PCB. 6. Replace oxygen regulator assembly.
7138	POST	A VENT INOP condition was declared, because three soft resets occurred in a 24-hour operational period.	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7139	POST	Software error	See Section 6.2.
7140	POST	Software error	See Section 6.2.
7141	POST	POST detected that a key was pressed when POST was run due to a soft reset. No keys should be pressed when POST is run due to a soft reset.	1. Release key. 2. Verify that keyboard cable is securely connected to UI display PCB. 3. Replace keyboard. 4. Replace controller PCB. 5. Replace UI display PCB.
7142	POST	Software error	See Section 6.2.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7143	POST	Software error	See Section 6.2.
7144	POST	A key was held down.	1. Release key. 2. Verify that keyboard cable is securely connected to UI display PCB. 3. Replace keyboard. 4. Replace controller PCB. 5. Replace UI display PCB.
7145	POST	Real-time clock error	Replace controller PCB.
7146	POST	Real-time clock error	Replace controller PCB.
7147	POST	BD POST did not operate as expected (possible microcontroller failure).	Replace controller PCB.
7148	POST	Software error	See Section 6.2.
7149	POST	Software error	See Section 6.2.
7150	POST	Software error	See Section 6.2.
7151	POST	Software error	See Section 6.2.
7152	POST	Software error	See Section 6.2.
7153	POST	General-purpose timer failure	Replace controller PCB.
7154	POST	Software error	See Section 6.2.
7155	POST	BD microcontroller failure	Replace controller PCB.
7156	POST	UI POST failed.	See previous diagnostic codes in log for corrective actions.
7157	POST	BD POST failed.	See previous diagnostic codes in log for corrective actions.
7158	POST	BD microcontroller clock failure	Replace controller PCB.
7159	POST	Failure to initialize UI panel	1. Replace UI display PCB. 2. Replace controller PCB.
7160	POST	Communications error (DUART device)	Replace controller PCB.
7161	POST	Communications error (DUART device)	Replace controller PCB.
7162	POST	Communications error (DUART device)	Replace controller PCB.
7163	POST	Communications error (DUART device)	Replace controller PCB.
7164	POST	Communications error (DUART device)	Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7165	POST	Communications error (DUART device)	Replace controller PCB.
7166	POST	Communications error (DUART device)	Replace controller PCB.
7167	POST	Communications error (DUART device)	Replace controller PCB.
7168	POST	General-purpose timer failure	Replace controller PCB.
7169	POST	Ventilator did not switch to ac after POST.	1. Verify that ac is acceptable. 2. Check LEDs on BBU PCB and power supply to determine presence of voltages. Replace BBU PCB, power supply, or power input component, as required.
7170	POST	Atmospheric pressure out of range	1. Make sure ventilator is operating within stated environmental specifications. 2. Replace pressure solenoid PCB.
7171	POST	Atmospheric pressure out of range	1. Make sure ventilator is operating within stated environmental specifications. 2. Replace pressure solenoid PCB.
7172	POST	Analog signal on UI section of controller PCB out of range	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
7173	POST	Analog signal on UI section of controller PCB out of range	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
7174	POST	Analog signal on BD section of controller PCB out of range	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
7175	POST	Cylinder pressure too low	1. Make sure inspiratory filter is not blocked. 2. Replace pressure solenoid PCB.
7176	POST	Cylinder pressure too high	1. Make sure inspiratory filter is not blocked. 2. Replace pressure solenoid PCB.
7177	POST	Exhalation limb temperature too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7178	POST	Exhalation limb temperature too high	1. Make sure room temperature is not too high. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
7179	POST	Software error	See Section 6.2.
7180	POST	Software error	See Section 6.2.
7181	POST	Software error	See Section 6.2.
7182	POST	Multiplexer failure on pressure solenoid PCB	Replace pressure solenoid PCB.
7183	POST	Multiplexer failure on pressure solenoid PCB	Replace pressure solenoid PCB.
7184	POST	Multiplexer failure on pressure solenoid PCB	Replace pressure solenoid PCB.
7185	POST	Multiplexer failure on pressure solenoid PCB	Replace pressure solenoid PCB.
7186	POST	Multiplexer lines shorted	Replace pressure solenoid PCB.
7187	POST	Multiplexer failure	Replace pressure solenoid PCB.
7188	POST	Multiplexer failure	Replace pressure solenoid PCB.
7189	POST	Multiplexer failure	Replace pressure solenoid PCB.
7190	POST	Multiplexer failure on controller PCB	Replace controller PCB.
7191	POST	Multiplexer failure on controller PCB	Replace controller PCB.
7192	POST	Multiplexer failure on controller PCB	Replace controller PCB.
7193	POST	Multiplexer failure on controller PCB	Replace controller PCB.
7194	POST	Clock failure on controller PCB	Replace controller PCB.
7195	POST	Motor controller chipset clock failure	Replace controller PCB.
7196	POST	Failure to zero exhalation flow sensor pressure transducer	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace pressure solenoid PCB. 3. Replace flow sensor. 4. Replace pressure solenoid PCB.
7197	POST	Power source indicator stuck on	Replace BBU PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7198	POST	Power source indicator stuck on	Replace BBU PCB.
7199	POST	EPROM or other hardware failure	1. Reinstall software. 2. Replace controller PCB.
7200	POST	EPROM or other hardware failure	1. Reinstall software. 2. Replace controller PCB.
7201-7206	POST	Software error	See Section 6.2.
7207	POST	Motor temperature too high	1. Clean or replace main fan filter. 2. Check for proper operation of main fan. 3. Replace motor/encoder.
7208	POST	An area of NVRAM that is not checked by a checksum is corrupted.	1. Restore NVRAM data. 2. Replace NVRAM.
7209	POST	Software error	See Section 6.2.
7210	POST	Software error	See Section 6.2.
7211	POST	Software error	See Section 6.2.
7212	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7213	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7214	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7215	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7216	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7217	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
7218	POST	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
7219	POST	Operating temperature < 5 ^{o}C	Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature.
7220	POST	Zeroing of oxygen regulator pressure transducer failed	Replace oxygen regulator pressure transducer.
7221-7233	POST	Software error	See Section 6.2.
7234	POST	Controller PCB ID invalid	Replace controller PCB.
7235	POST	Pressure solenoid PCB ID invalid	Replace pressure solenoid PCB.
7236	POST	BBU PCB ID invalid	Replace BBU PCB.
7237	POST	Loopback test performed on controller PCB during POST failed.	Replace controller PCB.
7238	POST	Loopback test performed on controller PCB during POST failed.	Replace controller PCB.
7239	POST	The voltage used to identify the *740/760* user interface is out of range.	1. Check all cable connections between the user interface and controller PCB. 2. Replace the UI display PCB. 3. Replace the controller PCB.
7240-7246	POST	Software error	See Section 6.2.
8000-8xxx	Library functions	Software error	See Section 6.2.
9000	Ongoing hardware checks	An out-of-bounds temperature measurement caused the reset	Determine which temperature was out of bounds using *Sensor data* function and referring to previous diagnostic code in log.
9001	Ongoing hardware checks	An out-of-bounds controller PCB voltage measurement caused the reset.	Replace controller PCB.
9002	Ongoing hardware checks	An out-of-bounds pressure solenoid PCB voltage caused the reset.	1. Determine which voltage is out of bounds through pressure solenoid PCB test connector. 2. Replace pressure solenoid PCB.
9003	Ongoing hardware checks	An out-of-bounds BBU PCB voltage caused the reset.	Replace BBU PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9004	Ongoing hardware checks	Current to PEEP pump too low	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
9005	Ongoing hardware checks	Current to PEEP pump too high	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
9006	Ongoing hardware checks	PEEP pump current problem	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
9007	Ongoing hardware checks	PEEP pump current problem	1. Replace PEEP pump. 2. Replace pressure solenoid PCB.
9008	Ongoing hardware checks	Motor temperature too high	1. Clean or replace main fan filter. 2. Check for proper operation of main fan. 3. Replace motor/encoder.
9009	Ongoing hardware checks	VENT INOP signal is active	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
9010	Ongoing hardware checks	Not Ventilating signal used in UI/ BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9011	Ongoing hardware checks	Battery current too low while charging	1. Replace applicable battery. 2. Replace BBU PCB.
9012	Ongoing hardware checks	Battery current too high while charging	1. Replace applicable battery. 2. Replace BBU PCB.
9013	Ongoing hardware checks	Main fan failure	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and attained a steady-state temperature. 2. Make sure ventilator lid is closed. 3. Make sure vents in unit are not blocked. 4. Clean or replace fan filter, as necessary. 5. Check that main fan/ventilator head harness connection is secure. 6. Replace main fan. 7. Replace air flow thermistor assembly.
9014	Ongoing hardware checks	A VENT INOP condition was declared	1. See previous diagnostic codes in log for corrective actions. 2. Run EST. 3. Replace controller PCB.
9015	Ongoing hardware checks	Not Ventilating signal used in UI/ BD communications is not in expected state	1. See Section 6.2. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9016	Ongoing hardware checks	Main alarm speaker failure	1. Check wiring to speaker. 2. Replace speaker. 3. Replace pressure solenoid PCB.
9017	Ongoing hardware checks	Safety valve current problem	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9018	Ongoing hardware checks	Safety valve current problem	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9019	Ongoing hardware checks	Safety valve current problem	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9020	Ongoing hardware checks	Safety valve current problem	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9021	Ongoing hardware checks	Safety valve failure	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9022	Ongoing hardware checks	Safety valve failure	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9023	Ongoing hardware checks	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
9024	Ongoing hardware checks	ALARM light failure	1. Replace UI display PCB. 2. Replace controller PCB.
9025	Ongoing hardware checks	Pressure solenoid PCB serial EPROM failure	Replace pressure solenoid PCB.
9026	Ongoing hardware checks	Pressure solenoid PCB serial EPROM failure	Replace pressure solenoid PCB.
9027	Ongoing hardware checks	Pressure solenoid PCB serial EPROM failure	Replace pressure solenoid PCB.
9028	Ongoing hardware checks	Pressure solenoid PCB serial EPROM failure	Replace pressure solenoid PCB.
9029	Ongoing hardware checks	One microcontroller recognizes a power loss, but other doesn't.	Replace controller PCB.
9030	Ongoing hardware checks	Safety valve control circuit failure	1. Replace pressure solenoid PCB. 2. Replace controller PCB
9031	Ongoing hardware checks	Message window (LCD panel) failure	Replace message window (LCD panel).
9033	Ongoing hardware checks	Failure to zero exhalation flow sensor pressure transducer	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9034	Ongoing hardware checks	Inspiration manifold temperature out of bounds	1. Make sure room temperature is within specifications. Make sure ventilator has warmed up and Tdel attained a steady state. 2. Check that inspiration manifold thermistor/ventilator head harness connection is secure. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
9035	Ongoing hardware checks	Internal ventilator temperature out of bounds	1. Make sure room temperature is within specifications. Make sure ventilator has warmed up and Tbox attained a steady state. 2. Replace pressure solenoid PCB.
9036	Ongoing hardware checks	Absolute inspiratory pressure out of bounds	Replace pressure solenoid PCB.
9037	Ongoing hardware checks	Absolute inspiratory pressure out of bounds	Replace pressure solenoid PCB.
9038	Ongoing hardware checks	Inspiration pressure out of bounds	1. Use *Sensor data* function to check P_i reading. 2. Replace pressure solenoid PCB.
9039	Ongoing hardware checks	Exhalation pressure out of bounds	1. Use *Sensor data* function to check P_i reading. 2. Replace pressure solenoid PCB.
9040	Ongoing hardware checks	Exhaled flow out of bounds	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
9041	Ongoing hardware checks	Atmospheric pressure out of bounds	1. Make sure ventilator is operating within stated environmental specifications. 2. Replace pressure solenoid PCB.
9042	Ongoing hardware checks	Oxygen regulator pressure out of bounds	1. Make sure oxygen source pressure is at least 40 psi. 2. Check for proper installation of oxygen regulator pressure transducer and connection of sensor to pressure solenoid PCB. 3. Replace oxygen regulator pressure transducer. 4. Replace oxygen regulator assembly. 5. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9043	Ongoing hardware checks	Oxygen percentage reading out of bounds	1. Make sure an oxygen sensor is installed and securely connected to ventilator head harness. 2. Check remaining sensor life (via service summary) and replace sensor if required. 3. Replace oxygen regulator assembly. 4. Replace pressure solenoid PCB.
9044-9060	Ongoing hardware checks	NVRAM failure	1. See Section 6.2. 2. Restore NVRAM data. 3. Replace NVRAM.
9061	Ongoing hardware checks	Both test and alert error logs cleared in memory or data was transferred to NVRAM.	No corrective action required: indicates that an error code location in NVRAM is now empty.
9062-9069	Ongoing hardware checks	NVRAM failure	1. See Section 6.2. 2. Restore NVRAM data. 3. Replace NVRAM.
9070	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9071	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9073	Ongoing hardware checks	Transducer autozero timeout error	Replace pressure solenoid PCB.
9074	Ongoing hardware checks	Piston not at expected location at start of inspiration	1. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace BBU PCB/ventilator head harness. 6. Check mesh of pinion gear with rack. Remesh as necessary. 7. Replace optoswitches.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9075	Ongoing hardware checks	Piston not retracting as expected	1. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace BBU PCB/ventilator head harness. 6. Check mesh of pinion gear with rack. Remesh as necessary. 7. Replace optoswitches.
9076	Ongoing hardware checks	Safety valve failed to close	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9077	Ongoing hardware checks	Safety valve failed to open	1. Replace safety valve. 2. Replace pressure solenoid PCB.
9078	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9079	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9080	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9081	Ongoing hardware checks	A high inspiration pressure condition was not stopped by software.	1. Make sure EXHAUST port is not blocked. 2. Use *Sensor data* function to check P_i reading. 3. Replace pressure solenoid PCB. 4. Replace controller PCB. 5. Replace BBU PCB. 6. Make sure safety valve can open. Replace as required.
9082	Ongoing hardware checks	Cylinder pressure out of bounds	1. Use *Sensor data* function to check P_{cyl} reading. 2. Replace pressure solenoid PCB.
9083	Ongoing hardware checks	Piston velocity out of bounds	1. Replace motor/encoder. 2. Replace pressure solenoid PCB. 3. Replace controller PCB.
9084	Ongoing hardware checks	Failure to autozero exhalation pressure transducer	1. Use *Sensor data* function to check P_e reading. 2. Check that autozero solenoid/main ventilator head harness connection is secure. 3. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9085	Ongoing hardware checks	Failure to autozero cylinder pressure transducer	1. Use *Sensor data* function to check P_{cyl} reading. 2. Check that autozero solenoid/main ventilator head harness connection is secure. 3. Replace pressure solenoid PCB.
9086	Ongoing hardware checks	Inspiration pressure out of bounds	1. Use *Sensor data* function to check P_i reading. 2. Replace pressure solenoid PCB.
9087	Ongoing hardware checks	Exhalation pressure out of bounds	1. Use *Sensor data* function to check P_e reading. 2. Replace pressure solenoid PCB.
9088	Ongoing hardware checks	Exhaled flow out of bounds	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
9089	Ongoing hardware checks	Oxygen regulator pressure transducer reading out of range	1. Make sure oxygen source pressure is at least 40 psi. 2. Calibrate oxygen regulator pressure transducer. 3. Check for proper installation of oxygen regulator pressure transducer and connection of sensor to pressure solenoid PCB. 4. Replace oxygen regulator pressure transducer. 5. Replace oxygen regulator assembly. 6. Replace pressure solenoid PCB.
9090	Ongoing hardware checks	Motor controller chipset failure	Replace controller PCB.
9091	Ongoing hardware checks	Motor controller chipset failure	Replace controller PCB.
9092	Ongoing hardware checks	Piston motion error	1. Perform gear mesh procedure, as required. 2. If piston scrapes, replace piston/cylinder assembly. 3. Replace motor/encoder. 4. Replace BBU PCB. 5. Replace controller PCB.
9093	Ongoing hardware checks	Unexpected interrupt to motor controller chipset	Replace controller PCB.
9094	Ongoing hardware checks	Unexpected interrupt to motor controller chipset	Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9095	Ongoing hardware checks	Motor fault reported to motor controller chipset	1. Replace piston/cylinder assembly. 2. Replace BBU PCB. 3. Replace motor/encoder. 4. Replace controller PCB.
9096	Ongoing hardware checks	Piston motion error	1. Verify operation of the home optoswitch. 2. Replace controller PCB. 3. Replace motor/encoder assembly.
9097	Ongoing hardware checks	Piston motion error	1. Verify operation of the end optoswitch. 2. Replace controller PCB. 3. Replace motor/encoder assembly.
9098	Ongoing hardware checks	Motor controller chipset failure	Replace controller PCB.
9099	Ongoing hardware checks	Piston motion error	Replace controller PCB.
9100	Ongoing hardware checks	Piston motion error	Replace controller PCB.
9101	Ongoing hardware checks	Piston motion error	1. Check gear pin. If piston is loose, replace piston/cylinder assembly. 2. Replace BBU PCB.
9102	Ongoing hardware checks	Piston motion error	1. Replace piston/cylinder assembly. 2. Replace BBU PCB.
9103	Ongoing hardware checks	Piston motion error	1. Check that home optoswitch/ventilator head harness connection is secure. 2. Replace controller PCB.
9104	Ongoing hardware checks	Piston motion error	1. Check that end optoswitch/ventilator head harness connection is secure. 2. Replace controller PCB.
9105	Ongoing hardware checks	Piston motion error	Replace controller PCB.
9106	Ongoing hardware checks	Atmospheric pressure out of bounds	1. Make sure ventilator is operating within stated environmental specifications. 2. Replace pressure solenoid PCB.
9107	Ongoing hardware checks	Motor controller chipset failure	Replace controller PCB.
9108	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.
9109	Ongoing hardware checks	Not Ventilating signal used in UI/BD communications is not in expected state.	1. See Section 6.2. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9110	Ongoing hardware checks	Exhalation solenoid seems to be stuck open	1. Replace exhalation solenoid. 2. Replace pressure solenoid PCB.
9111	Ongoing hardware checks	CAUTION light control bit not in expected state	1. Replace UI display PCB. 2. Replace controller PCB.
9112	Ongoing hardware checks	CAUTION light control bit not in expected state	1. Replace UI display PCB. 2. Replace controller PCB.
9113	Ongoing hardware checks	Real-time clock failure	Replace controller PCB.
9114	Ongoing hardware checks	Real-time clock failure	Replace controller PCB.
9115-9124	Ongoing hardware checks	Bad NVRAM data or NVRAM	1. See Section 6.2. 2. Restore NVRAM data. 3. Replace NVRAM.
9125	Ongoing hardware checks	Exhalation flow sensor pressure transducer failure	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Replace pressure solenoid PCB.
9126	Ongoing hardware checks	Mismatch between BD and UI microprocessors' inspiration pressure readings	1. Verify that sampling tubes are connected to correct pressure solenoid PCB connectors. 2. Replace pressure solenoid PCB. 3. Replace controller PCB.
9127	Ongoing hardware checks	Mismatch between BD and UI microprocessors' exhalation pressure readings	1. Verify that sampling tubes are connected to correct pressure solenoid PCB connectors. 2. Replace pressure solenoid PCB. 3. Replace controller PCB.
9128	Ongoing hardware checks	Not Ventilating signal used in UI/ BD communications is not in expected state.	Replace controller PCB.
9129	Ongoing hardware checks	Not Ventilating signal used in UI/ BD communications is not in expected state.	Replace controller PCB.
9130	Ongoing hardware checks	Exhaled flow out of bounds	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9131	Ongoing hardware checks	Cylinder pressure reading out of range	1. Make sure inspiratory filter outlet is not blocked and air intake filter is not occluded. 2. Replace pressure solenoid PCB.
9132	Ongoing hardware checks	Flow sensor pressure transducer reading too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Verify that tubes between flow sensor and pressure transducer are securely connected. 3. Make sure EXHAUST port is not blocked. 4. Replace pressure solenoid PCB.
9133	Ongoing hardware checks	Flow sensor pressure transducer reading too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Verify that tubes between flow sensor and pressure transducer are securely connected. 3. Make sure EXHAUST port is not blocked. 4. Replace pressure solenoid PCB.
9134	Ongoing hardware checks	Flow sensor pressure transducer reading too low	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Verify that tubes between flow sensor and pressure transducer are securely connected. 3. Make sure EXHAUST port is not blocked. 4. Replace pressure solenoid PCB.
9135	Ongoing hardware checks	Flow sensor pressure transducer reading too high	1. Make sure room temperature is not too high. 2. Verify that tubes between flow sensor and pressure transducer are securely connected. 3. Make sure EXHAUST port is not blocked. 4. Replace pressure solenoid PCB.
9138	Ongoing hardware checks	+24 V to UI display PCB too low	1. Replace UI display PCB. 2. Replace controller PCB.
9139	Ongoing hardware checks	+24 V to UI display PCB too high	1. Replace UI display PCB. 2. Replace controller PCB.
9140	Ongoing hardware checks	+5 V to UI display PCB too low	1. Replace UI display PCB. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9141	Ongoing hardware checks	+5 V to UI display PCB too high	1. Replace UI display PCB. 2. Replace controller PCB.
9142	Ongoing hardware checks	Software/UI display PCB revision mismatch	1. Make sure UI display PCB is for a *700 Series Ventilator System*. 2. Replace UI display PCB. 3. Replace controller PCB.
9143	Ongoing hardware checks	Software/UI display PCB revision mismatch	1. Make sure UI display PCB is for a *700 Series Ventilator System*. 2. Replace UI display PCB. 3. Replace controller PCB.
9144	Ongoing hardware checks	+1.2 V reference from pressure solenoid PCB too low	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9145	Ongoing hardware checks	+1.2 V reference from pressure solenoid PCB too high	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9146	Ongoing hardware checks	+15 V from pressure solenoid PCB too low	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9147	Ongoing hardware checks	+15 V from pressure solenoid PCB too high	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9148	Ongoing hardware checks	-15 V from pressure solenoid PCB too low	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9149	Ongoing hardware checks	-15 V from pressure solenoid PCB too high	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9150	Ongoing hardware checks	+1.2 V reference from pressure solenoid PCB too low	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9151	Ongoing hardware checks	+1.2 V reference from pressure solenoid PCB too high	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9152	Ongoing hardware checks	+15 V from BBU PCB too low	1. Replace BBU PCB. 2. Replace controller PCB.
9153	Ongoing hardware checks	+15 V from BBU PCB too high	1. Replace BBU PCB. 2. Replace controller PCB.
9154	Ongoing hardware checks	+5 V from BBU PCB too low	1. Replace BBU PCB. 2. Replace controller PCB.
9155	Ongoing hardware checks	+5 V from BBU PCB too high	1. Replace BBU PCB. 2. Replace controller PCB.
9156	Ongoing hardware checks	+5 V to breath delivery motor controller circuits too low	1. Replace pressure solenoid PCB. 2. Replace controller PCB.
9157	Ongoing hardware checks	+5 V to breath delivery motor controller circuits too high	1. Replace pressure solenoid PCB. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9158	Ongoing hardware checks	+2.5 V reference to breath delivery motor controller circuits too low	Replace controller PCB.
9159	Ongoing hardware checks	+2.5 V reference to breath delivery motor controller circuits too high	Replace controller PCB.
9160	Ongoing hardware checks	Oxygen regulator pressure transducer reading too low	1. Calibrate oxygen regulator pressure transducer. 2. Replace oxygen regulator pressure transducer. 3. Replace oxygen regulator assembly. 4. Replace pressure solenoid PCB.
9161	Ongoing hardware checks	Oxygen regulator pressure transducer reading too high	1. Verify that oxygen supply pressure is not too high. 2. Calibrate oxygen regulator pressure transducer. 3. Replace oxygen regulator pressure transducer. 4. Replace oxygen regulator assembly. 5. Replace pressure solenoid PCB.
9162	Ongoing hardware checks	Oxygen regulator pressure transducer reading too low	1. Calibrate oxygen regulator pressure transducer. 2. Replace oxygen regulator pressure transducer. 3. Replace oxygen regulator assembly. 4. Replace pressure solenoid PCB.
9163	Ongoing hardware checks	Oxygen regulator pressure transducer reading too high	1. Verify that oxygen supply pressure is not too high. 2. Calibrate oxygen regulator pressure transducer. 3. Replace oxygen regulator pressure transducer. 4. Replace oxygen regulator assembly. 5. Replace pressure solenoid PCB.
9164	Ongoing hardware checks	Safety valve stuck closed	1. Check that safety valve/ventilator head harness connection is secure. 2. Replace safety valve. 3. Replace pressure solenoid PCB.
9165	Ongoing hardware checks	Safety valve stuck closed	1. Check that safety valve/ventilator head harness connection is secure. 2. Replace safety valve. 3. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9166	Ongoing hardware checks	Atmospheric pressure measurement out of range	1. Make sure ventilator is operating within stated environmental specifications. 2. Verify that tube between inspiration manifold and inspiration pressure transducer is securely connected. 3. Replace pressure solenoid PCB. 4. Replace controller PCB.
9167	Ongoing hardware checks	Atmospheric pressure measurement out of range	1. Make sure ventilator is operating within stated environmental specifications. 2. Verify that tube between inspiration manifold and inspiration pressure transducer is securely connected. 3. Replace pressure solenoid PCB. 4. Replace controller PCB.
9168	Ongoing hardware checks	Motor controller chipset failure	Replace controller PCB.
9169	Ongoing hardware checks	Piston did not move forward for 3 consecutive breaths	1. Run SST or EST to make sure ventilator is capable of moving piston. 2. Check harness from controller PCB to motor/encoder. 3. Replace controller PCB. 4. Replace motor/encoder assembly.
9170	Ongoing hardware checks	Piston did not move forward for 3 consecutive breaths	1. Run SST or EST to make sure ventilator is capable of moving piston. 2. Check harness from controller PCB to motor/encoder. 3. Replace controller PCB. 4. Replace motor/encoder assembly.
9171	Ongoing hardware checks	EPROM on pressure solenoid PCB uninitialized or data corrupted	Replace pressure solenoid PCB.
9172	Ongoing hardware checks	EPROM on pressure solenoid PCB uninitialized or data corrupted	Replace pressure solenoid PCB.
9173	Ongoing hardware checks	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
9174	Ongoing hardware checks	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
9175	Ongoing hardware checks	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
9176	Ongoing hardware checks	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
9177-9180	POST	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
9181	Ongoing hardware checks	The voltage used to identify the *740/760* user interface is out of range.	1. Check all cable connections between the user interface and controller PCB. 2. Replace the user interface. 3. Replace the controller PCB.
9182-9185	POST	NVRAM failure	1. Replace NVRAM. 2. Replace controller PCB.
9186	Ongoing hardware checks	Bad DAC value during P_e autozero	Replace controller PCB.
9187	Ongoing hardware checks	Bad DAC value during P_{cyl} autozero	Replace controller PCB.
10000	Interrupt routines	Software error	See Section 6.2.
10001	Interrupt routines	Software error	See Section 6.2.
10002	Interrupt routines	1. Microcontroller failure 2. Software error	1. Replace controller PCB. 2. See Section 6.2.
10003	Interrupt routines	Memory or microcontroller failure	Replace controller PCB.
10004	Interrupt routines	Microcontroller failure	Replace controller PCB.
10005	Interrupt routines	Microcontroller failure	Replace controller PCB.
10006	Interrupt routines	1. Software error 2. Microcontroller failure	1. See Section 6.2. 2. Replace controller PCB.
10007	Interrupt routines	1. Software error 2. Hardware failure	1. See Section 6.2. 2. Replace controller PCB.
10008	Interrupt routines	1. Software error 2. Hardware failure	1. See Section 6.2. 2. Replace controller PCB.
10009	Interrupt routines	1. Software error 2. Hardware failure	1. See Section 6.2. 2. Replace controller PCB.
10010	Interrupt routines	Power was lost immediately after ventilator power was switched on.	1. Replace power supply. 2. Replace BBU PCB.
10011	Interrupt routines	Power was lost immediately after ventilator power was switched on.	1. Replace power supply. 2. Replace BBU PCB.
11000	SST/EST	Inspiration pressure out of bounds	Replace pressure solenoid PCB.
11001	SST/EST	Exhalation pressure out of bounds	1. Verify the ports were blocked correctly during testing. 2. Replace pressure solenoid PCB.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
11002	SST/EST	Exhaled flow out of bounds	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
11003-11015	SST/EST	Software error	See Section 6.2.
11016	SST/EST	Inspiration pressure out of bounds	1. Verify the ports were blocked correctly during testing. 2. Replace pressure solenoid PCB.
11017	SST/EST	Exhalation pressure out of bounds	1. Verify the ports were blocked correctly during testing. 2. Replace pressure solenoid PCB.
11018	SST/EST	Exhaled flow out of bounds	1. Make sure room temperature is within specifications. Make sure that ventilator has warmed up and exhaled flow attained a steady-state temperature. 2. Replace flow sensor. 3. Replace pressure solenoid PCB.
11019-11131	SST/EST	Software error	See Section 6.2.
11132	SST/EST	Software or motor/encoder error	1. See Section 6.2. 2. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 3. Check mesh of pinion gear with rack. Remesh as necessary. 4. Replace motor/encoder. 5. Replace controller PCB. 6. Replace BBU PCB. 7. Replace BBU PCB/ventilator head harness. 8. Replace optoswitches.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
11133	SST/EST	Software or motor/encoder error	1. See Section 6.2. 2. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 3. Check mesh of pinion gear with rack. Remesh as necessary. 4. Replace motor/encoder. 5. Replace controller PCB. 6. Replace BBU PCB. 7. Replace BBU PCB/ventilator head harness. 8. Check mesh of pinion gear with rack. Remesh as necessary. 9. Replace optoswitches.
11134	SST/EST	Software or motor/encoder error	1. See Section 6.2. 2. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 3. Check mesh of pinion gear with rack. Remesh as necessary. 4. Replace motor/encoder. 5. Replace controller PCB. 6. Replace BBU PCB. 7. Replace BBU PCB/ventilator head harness. 8. Check mesh of pinion gear with rack. Remesh as necessary. 9. Replace optoswitches.
11135-11143	SST/EST	Software error	See Section 6.2.
11144	SST/EST	EST failed, and a VENT INOP condition was declared.	See previous diagnostic codes in log for corrective actions. Repair ventilator and rerun EST.
11145	SST/EST	Software error	See Section 6.2.
11146	SST/EST	Software error	See Section 6.2.
11147	SST/EST	SST failed, and a VENT INOP condition was declared.	See previous diagnostic codes in log for corrective actions. Repair ventilator and rerun EST.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
11148	SST/EST	Software or motor/encoder error	1. If piston/cylinder was recently replaced, make sure calibration constants were correctly input. 2. Replace motor/encoder. 3. Replace controller PCB. 4. Replace BBU PCB. 5. Replace BBU PCB/ventilator head harness. 6. Check mesh of pinion gear with rack. Remesh as necessary. 7. Replace optoswitches.
11149-11194	SST/EST	Software error	See Section 6.2.
11195	SST/EST	Illegal value in tubing type field in NVRAM	1. Rerun SST. 2. Replace NVRAM.
11196	SST/EST	Software error	See Section 6.2.
11197	SST/EST	Software error	See Section 6.2.
11198	SST/EST	Software error	See Section 6.2.
11199	SST	Software error	See Section 6.2.
11200	EST	Failure to zero exhalation flow sensor pressure transducer	1. Replace exhalation flow sensor. 2. Replace pressure solenoid PCB.
11201, 11202	Communications test	Software error	See Section 6.2.
11203	Calibration	Software error	See Section 6.2.
11204	Calibration/EST	Software error	See Section 6.2.
11205	EST	Software error	See Section 6.2.
11206-11211	Battery load test	Software error	See Section 6.2.
11212, 11213	Communications test	Software error	See Section 6.2.
11214	SST/EST	Software error	See Section 6.2.
11215	SST	Software error	See Section 6.2.
11216-11219	Calibration	Software error	See Section 6.2.
12000	Communications routines	Software error	See Section 6.2.
12001	Communications routines	Software error	See Section 6.2.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
12002	Communications routines	Software error	See Section 6.2.
12003	Communications routines	Corrupt data packet	1. Verify communications configuration on PC side. 2. Check communications cabling.
12004	Communications routines	Corrupt data packet. Five unsuccessful attempts were made to transmit it.	1. Verify communications configuration on PC side. 2. Check communications cabling.
12005	Communications routines	Software error	See Section 6.2.
12006	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12007	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12008	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12009	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12010	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12011	Communications routines	Communications failure	1. Verify communications configuration on PC side. 2. Check communications cabling.
12012	Communications routines	Software error	See Section 6.2.
12013	Communications routines	Communications failure	Replace controller PCB.
12014	Communications routines	Software error	See Section 6.2.
13000	Ventilator status	Ventilator reset occurred while entering SST	See Section 6.3.
13001	Ventilator status	Ventilator reset occurred while entering EST	See Section 6.3.
13002	Ventilator status	Ventilator reset occurred during EST	See Section 6.3.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
13003	Ventilator status	Ventilator reset occurred during SST	See Section 6.3.
13004	Ventilator status	Ventilator reset occurred during calibration	See Section 6.3.
13005	Ventilator status	Ventilator reset occurred in standby mode	See Section 6.3.
13006	Ventilator status	Ventilator reset occurred in normal ventilation mode	See Section 6.3.
13007	Ventilator status	Ventilator reset occurred while waiting for user to confirm settings	See Section 6.3.
13008	Ventilator status	SST passed	None required.
13009	Ventilator status	SST incomplete	None required.
13010	Ventilator status	SST fault	None required.
13011	Ventilator status	SST failure	None required.
13012	Ventilator status	EST passed	None required.
13013	Ventilator status	EST incomplete	None required.
13014	Ventilator status	EST fault	None required.
13015	Ventilator status	EST failure	None required.
13016	Ventilator status	Ventilator reset occurred in normal ventilation mode	See Section 6.3.
13017	Ventilator status	Ventilator reset occurred while waiting for user to confirm settings	See Section 6.3.
13018	Ventilator status	SST failed and ventilator restarted with MENU key pressed down, causing the ventilator to enter VENT INOP	None required.
13019	Ventilator status (technical alert -- ABNORMAL RESTART)	A field in the setting area of NVRAM is corrupted (for example, bad NVRAM data downloaded to ventilator).	The ventilator resets, returns settings to default values, and stores the error in NVRAM. Check and confirm settings, including alarms.

Table 6-1: Diagnostic codes (continued)

Code	Software	Possible cause	Corrective action
14000	Communications failure	An invalid request was received on Port A or Port B	1. Check that external communications device is valid for use with the *700 Series* Ventilator. 2. Check all cable connections between the Communications panel, Communications option assembly, and controller PCB. 3. Replace Communications option assembly.
14001-14xxx	Communications failure	Software error	See Section 6.2.

Alarm messages

This section describes how to respond to ventilator alarms. It also lists, in alphabetic order, messages displayed by the ventilator when it detects alarm conditions.

7.1 Alarm classifications

Alarms in the *700 Series* Ventilators are classified by priority (*high-priority* or *medium-priority*); this classification determines how the ventilator responds (Table 7-1). Some alarms are triggered by a ventilator setting or patient condition, and they can occur in the usual course of patient care. Others are triggered by the ventilator's built-in ongoing tests (BIOT) and may indicate that the ventilator requires service; some of these are known as *technical alerts*. When the ventilator declares a technical alert, it not only displays a message, but it also places an associated diagnostic code into the alert log (Section 4.1.4).

Table 7-1: How the ventilator responds to alarm conditions

Priority	Meaning	Displays	Audible alarm
High	Requires immediate attention to ensure patient safety	Red ALARM indicator flashes. Message in message window.	Repeating sequence of three, then two beeps
Medium	Requires prompt attention	Yellow CAUTION indicator flashes. Message in message window.	Repeating sequence of three beeps

NOTE:

The highest-priority active alarm always flashes on the first line of the message window. If no alarm is active, the first line displays the highest-priority alarm that was automatically reset. You can use the menu function to view all remaining active and autoreset alarms (see the *700 Series Ventilator System Operator's Manual* for more information on the MENU key).

7.2 Responding to alarms

1. Silence the audible alarm for 2 minutes (where possible) by pressing the alarm silence key.
2. Correct the condition, if necessary, referring to Table 7-2. You may want to check the contents of the alert and test logs (accessible through the service menu, Section 4.2) for related diagnostic codes. These procedures are sequenced to correct the most probable malfunction or to present the most efficient corrective action first. The proposed fixes listed, however, may not always correct the particular problem.

NOTE:

Use the service menu *Sensor data* function (Section 4.2.1) to help confirm the failure of suspect components.

3. If necessary, clear the message or reset the alarm by pressing the alarm reset key (see Table 7-2). Unless otherwise indicated, alarms are reset automatically when the triggering condition is eliminated. For specifics about how alarm silencing and alarm resetting works, see the *700 Series Ventilator System Operator's Manual*.

NOTE:

A temperature-related technical alert may be the first sign of a hardware failure. It may signal a more serious condition that will cause the ventilator to be reset.

Table 7-2: Alarm messages

When you see this message:	It means...	Do this...
ABNORMAL RESTART (no diagnostic code logged)	High-priority alarm. The ventilator was reset, typically due to a ventilator check detecting an error condition. If the ventilator detects three such conditions in 24 operating hours, a ventilator inoperative condition is declared. Alarm does not autoreset; you must press alarm reset key.	Review alert and test logs to determine cause of reset. Service as necessary. NOTE: If the ventilator was reset under software control, a diagnostic code will be logged.
AIR INTAKE ABSENT (diagnostic code 6037)	High-priority alarm. Technical alert. Air intake filter switch open. Alarm does not autoreset; you must press alarm reset key.	1. Verify that air intake filter is installed and that it engages air intake filter switch. 2. Check secureness of air intake filter switch/ventilator head harness connection. 3. Replace air intake filter. 4. Replace air intake filter switch. 5. Replace pressure solenoid PCB.
AIR INTAKE BLOCKED (diagnostic code 6021)	High-priority alarm. Technical alert. Ventilator has detected above-normal resistance at air intake filter during POST after power switched on. Alarm does not autoreset; you must press alarm reset key.	1. Check patient. 2. Check for visible occlusions (for example, a curtain, clothing, or furniture blocking air intake). 3. Replace air intake filter.
APNEA (no diagnostic code logged)	High-priority alarm. Patient has not triggered a breath within apnea interval (can only occur in SPONT mode). Autoreset when patient triggers 2 consecutive breaths.	1. Check patient. 2. Consider switching from SPONT mode.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
BATTERY FUSE FAILED (diagnostic code 6020)	High-priority alarm. Technical alert. Open circuit detected in internal battery output. Alarm does not autoreset; you must press reset key. Once reset, alarm is not reannunciated.	1. Make sure internal battery was not removed during operation. 2. Replace internal battery.
BAT NOT CHARGING (diagnostic code 6006)	High-priority alarm. Technical alert. Battery voltage has not increased during past hour. Alarm does not autoreset; you must press alarm reset key.	1. Check connections and charge of batteries. 2. Replace applicable battery. 3. Replace BBU PCB.
CONTACT SERVICE (diagnostic code 6026)	High-priority alarm. Technical alert. Flow sensor offset has changed by an unexpectedly large value. Alarm does not autoreset.	1. Verify that tubes between flow sensor and pressure transducer are securely connected. 2. Make sure EXHAUST port is not blocked. 3. Check flow sensor calibration constants. 4. Replace flow sensor. 5. Replace pressure solenoid PCB.
CONTACT SERVICE (diagnostic code 6027)	High-priority alarm. Technical alert. Safety valve should be closed, but measured current is too low. Alarm does not autoreset.	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
CONTACT SERVICE (diagnostic code 6028)	High-priority alarm. Technical alert. Safety valve should be closed, but measured current is too high. Alarm does not autoreset.	1. Check that safety valve/ventilator head harness connection is secure. 2. Check safety valve resistance (10.5 to 14 Ω). 3. Replace safety valve. 4. Replace pressure solenoid PCB.
CONTACT SERVICE (diagnostic code 6029)	High-priority alarm. Technical alert. No current to ALARM light when it should be on. Autoreset on subsequent ALARM light state change, after triggering condition disappears.	1. Replace UI display PCB. 2. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6030)	High-priority alarm. Technical alert. There is current to ALARM light when it should be off. Autoreset on subsequent ALARM light state change, after triggering condition disappears.	1. Replace UI display PCB. 2. Replace controller PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
CONTACT SERVICE (diagnostic code 6031)	High-priority alarm. Technical alert. No current to CAUTION light when it should be on. Autoreset on subsequent CAUTION light state change, after triggering condition disappears.	1. Replace UI display PCB. 2. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6032)	High-priority alarm. Technical alert. There is current to CAUTION light when it should be off. Autoreset on subsequent CAUTION light state change, after triggering condition disappears.	1. Replace UI display PCB. 2. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6033)	High-priority alarm. Technical alert. Battery current low. Autoreset when battery current within range.	1. Replace appropriate battery. 2. Replace BBU PCB. 3. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6034)	High-priority alarm. Technical alert. Battery current high. Autoreset when battery current within range.	1. Replace appropriate battery. 2. Replace BBU PCB. 3. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6035)	High-priority alarm. Technical alert. PEEP pump current low. Autoreset when PEEP pump current within range.	1. Verify that resistance of PEEP pump is between 12 and 15 Ω measured when pump is at ambient temperature. If it is not replace pump. 2. Check continuity of wiring to PEEP pump. Replace harness if necessary. 3. Replace pressure solenoid PCB. 4. Replace BBU PCB. 5. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6036)	High-priority alarm. Technical alert. PEEP pump current high. Autoreset when PEEP pump current within range.	1. Verify that resistance of PEEP pump is between 12 and 15 Ω measured when pump is at ambient temperature. If it is not replace pump. 2. Check continuity of wiring to PEEP pump. Replace harness if necessary. 3. Replace pressure solenoid PCB. 4. Replace BBU PCB. 5. Replace controller PCB.
CONTACT SERVICE (diagnostic code 6038)	High-priority alarm. Technical alert. NVRAM failure. Alarm does not autoreset.	1. Replace NVRAM. 2. Replace controller PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
CONTACT SERVICE (diagnostic codes 6043-6046)	High-priority alarm. Technical alert. BBU signal conflict: signals indicate both battery and AC power operation. Alarm does not autoreset.	1. Verify AC power to the ventilator. 2. Verify battery voltage. 3. Check that connections between the BBU and controller PCBs are secure. 4. Replace BBU PCB. 5. Replace controller PCB.
CONTINUOUS HI PRES (diagnostic code 6003)	High-priority alarm. Technical alert. HIGH PRESSURE alarm is active but circuit pressure has not dropped below HIGH PRESSURE setting. This points to a failure to open the exhalation valve. Alarm does not autoreset. The safety valve opens (the patient breathes room air, unassisted by the ventilator).	1. Check patient; provide alternate ventilation. 2. Make sure EXHAUST port is not blocked. 3. Replace exhalation solenoid. 4. Replace pressure solenoid PCB. 5. Replace exhalation valve.
DELIV GAS HI TEMP (diagnostic code 6018)	HIgh-priority alarm. Technical alert. Inspiration manifold temperature too high. Autoreset when temperature within range.	1. Make sure room temperature is not too high. 2. Check wiring from thermistor to pressure solenoid PCB. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
DELIV GAS LOW TEMP (diagnostic code 6017)	High-priority alarm. Technical alert. Inspiration manifold temperature too low. Autoreset when temperature within range.	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tdel attained a steady state. 2. Check wiring from thermistor to pressure solenoid PCB. 3. Replace inspiration manifold thermistor. 4. Replace pressure solenoid PCB.
DISCONNECT (no diagnostic code logged)	High-priority alarm. Measured exhaled tidal volume is 15% or less of delivered tidal volume for 4 consecutive breaths. Autoreset when exhaled tidal volume is greater than 15% of delivered tidal volume for 1 breath.	1. Check patient. 2. Check ventilator breathing circuit connections. 3. Make sure flow sensor/pressure transducer tubes are connected. 4. If flow sensor was recently replaced, make sure calibration constants were correctly entered. 5. Replace exhalation flow sensor. 6. Replace pressure solenoid PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
EXH CCT HI TEMP (diagnostic code 6012)	High-priority alarm. Technical alert. Exhalation limb temperature too high. The ventilator continues to annunciate this alarm while the condition persists. Autoreset when temperature within range.	1. Check connections of exhalation heater and thermistor assemblies. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
	NOTE: Be aware that spirometry may be affected (monitored values may be higher than actual).	
EXH CCT LOW TEMP (diagnostic code 6011)	High-priority alarm. Technical alert. Exhalation limb temperature too low. The ventilator continues to annunciate this alarm while the condition persists. Autoreset when temperature is within range.	1. Check connections of exhalation heater and thermistor assemblies. 2. Replace exhalation heater assembly. 3. Replace exhalation thermistor assembly. 4. Replace pressure solenoid PCB.
	NOTE: Be aware that spirometry may be affected (monitored values may be lower than actual).	
FAN FAILED ALERT (diagnostic code 6004)	High-priority alarm. Technical alert. Fan filter occluded or fan not operational. The ventilator continues to annunciate this alarm while the condition persists. Alarm does not autoreset; you must press alarm reset key.	1. Make sure main fan is operating. 2. Make sure room temperature is not too low. Make sure that ventilator has warmed up and attained a steady-state temperature (*after* removing the ventilator from its packaging). 3. Make sure ventilator lid is securely closed and that the lid gasket is not torn. 4. Make sure vents in unit are not blocked. 5. Replace fan filter, as necessary. 6. Check secureness of main fan/ ventilator head harness connection. 7. Replace main fan. 8. Replace air flow thermistor assembly.
	NOTE: Diagnostic code 6004 can be caused by a fan that draws no current *or* by insufficient air flow into the ventilator and across the air flow thermistor. If the fan is operating, the cause of this diagnostic code is insufficient air flow into the ventilator.	

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
FLO SENSOR HI TEMP (diagnostic code 6014)	High-priority alarm. Technical alert. Temperature at exhalation flow sensor pressure transducer too high. The ventilator continues to annunciate this alarm while the condition persists. Autoreset when temperature within range.	1. Make sure room temperature is not too high. 2. Replace pressure solenoid PCB.
FLO SENSOR LO TEMP (diagnostic code 6013)	High-priority alarm. Technical alert. Temperature at exhalation flow sensor pressure transducer too low. The ventilator continues to annunciate this alarm while the condition persists. Autoreset when temperature within range.	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Txdcr attained a steady state. 2. Replace pressure solenoid PCB.
HI BBU TEMP ALERT (diagnostic code 6016)	High-priority alarm. Technical alert. Temperature measured on BBU PCB too high. Autoreset when temperature within range.	1. Make sure power supply fan harness is securely connected. 2. Replace power supply fan. 3. Replace BBU PCB.
HI EX TIDAL VOLUME (no diagnostic code logged)	Medium-priority alarm. Exhaled volume for 3 of 4 consecutive breaths was above HIGH TIDAL VOLUME setting. Autoreset when 3 of 4 consecutive breaths are within alarm setting.	1. Check patient. 2. Consider appropriate HIGH TIDAL VOLUME, TIDAL VOLUME, and SUPPORT PRESSURE settings. 3. If flow sensor was recently replaced, make sure calibration constants were correctly entered. 4. Replace exhalation flow sensor. 5. Replace pressure solenoid PCB.
HI RESP RATE (no diagnostic code logged)	Medium-priority alarm. Monitored respiratory rate higher than HIGH RATE setting. Autoreset when monitored respiratory rate less than or equal to alarm setting.	1. Check patient. 2. Check for ventilator breathing circuit leak that could cause autocycling. 3. Consider appropriate HI RATE, RESPIRATORY RATE, and TRIGGER SENSITIVITY settings. 4. Consider adequacy of ventilatory support and patient comfort. 5. Replace controller PCB.
HI SYS TEMP ALERT (diagnostic code 6010)	High-priority alarm. Technical alert. Temperature inside ventilator enclosure too high. Autoreset when temperature within range.	1. Make sure room temperature is not too high. 2. Make sure vents in unit are not blocked. 3. Make sure main fan is operating properly. Clean or replace fan filter, as necessary. 4. Replace pressure solenoid PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
HIGH PRESSURE (no diagnostic code logged)	High-priority alarm. Two consecutive breaths were truncated because ventilator breathing circuit pressure reached HIGH PRESSURE setting. (Inspiration phase ends and exhalation valve opens to prevent excessive pressure.) Autoreset when circuit pressure is less than alarm setting for 5 breaths. Cannot be silenced if alarm condition persists.	1. Check patient. 2. Check for water in inspiratory limb or for kinked tubing. 3. Consider appropriate HIGH PRESSURE and ventilator settings. 4. Replace pressure solenoid PCB. 5. Replace controller PCB.
KEYBOARD FAILED (diagnostic code 6008)	High-priority alarm. Technical alert. A key was held down longer than expected. Alarm does not autoreset.	1. Verify that keyboard cable is securely connected to UI display PCB. 2. Replace keyboard. 3. Replace controller PCB. 4. Replace UI display PCB.
LO EX TIDAL VOLUME (no diagnostic code logged)	Medium-priority alarm. Monitored tidal volume less than LOW TIDAL VOLUME setting for 3 out of 4 consecutive breaths. If LOW TIDAL VOLUME ALARM setting = 0 and breath type is PCV or PSV, this alarm indicates that monitored tidal volume is less than 3 mL for 3 out of 4 consecutive breaths. Autoreset when monitored value is at least equal to alarm setting for 3 out of 4 consecutive breaths, or (if LOW TIDAL VOLUME = 0 and breath type is PCV or PSV) when monitored value is greater than 3 mL for 3 out of 4 consecutive breaths.	1. Check patient. 2. Consider appropriate LOW TIDAL VOLUME, TIDAL VOLUME, and SUPPORT PRESSURE settings. 3. If flow sensor was recently replaced, make sure calibration constants were correctly entered. 4. Replace exhalation flow sensor. 5. Replace pressure solenoid PCB. 6. Replace controller PCB.
LOSS AC POWER (no diagnostic code logged)	Medium-priority alarm. Loss of ac power, although battery backup available. Autoreset after 2 minutes, or when ac power restored.	1. Restore ac power, if possible. 2. Check LEDs on BBU PCB to determine presence of voltages. Replace BBU PCB, power supply, or power input component as required.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
LOSS OF POWER (diagnostic code 6001)	High-priority alarm. Technical alert. The ac supply was lost and the batteries are so low that all power may be lost. The unit will shut down in 5 minutes. Autoreset when ac power is restored or battery power is restored. Alarm sounds until autoreset and for at least 2 minutes following loss of both battery and ac power. NOTE: Actual battery backup time remaining depends on battery condition and ventilator settings.	1. Restore ac power, if possible. 2. Check battery connections. 3. Replace batteries (internal and external, if installed) as necessary. 4. Replace BBU PCB.
LOW BBU TEMP ALERT (diagnostic code 6015)	High-priority alarm. Technical alert. Temperature measured on BBU PCB too low. Autoreset when temperature within range.	1. Replace BBU PCB. 2. Replace power supply.
LOW EX MINUTE VOLUME (no diagnostic code logged)	Medium-priority alarm. Monitored minute volume less than LOW MINUTE VOLUME setting. Autoreset when monitored value is at least equal to alarm setting.	1. Check patient. 2. Consider appropriate LOW MINUTE VOLUME and ventilator settings.
LOW EXT BATTERY (no diagnostic code logged)	High-priority alarm. Low external battery voltage detected during POST, although ac power is sufficient. This alarm occurs only when the internal battery is also low or missing. Autoreset after 2 minutes or when external battery is replaced. Once reset, alarm is not reannunciated.	1. Verify reliable ac power source. 2. Check external battery connections. 3. Replace external battery. 4. Replace BBU PCB.
LOW INSP PRESSURE (no diagnostic code logged)	High-priority alarm. Monitored circuit pressure never rises above LOW INSP PRESSURE setting during inspiration (this alarm is only active during A/C and SIMV modes). Autoreset when circuit pressure is at least equal to alarm setting during inspiration.	1. Check patient. 2. Check for ventilator breathing circuit disconnect. 3. Consider appropriate LOW INSP PRESSURE and ventilator settings.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
LOW INSP PRESSURE1 (diagnostic code 6023)	High-priority alarm. Technical alert. Exhalation pressure transducer reading (P_e) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate. Autoreset when pressure within range.	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Make sure air intake filter is not occluded. 3. Check reasonableness of P_e reading using *Sensor data* menu while ventilation is occurring. Perform a P_e gain calibration as required. 4. Replace pressure solenoid PCB.
LOW INSP PRESSURE2 (diagnostic code 6024)	High-priority alarm. Technical alert. Inspiration pressure transducer reading (P_i) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate. Autoreset when pressure within range.	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Make sure air intake filter is not occluded. 3. Check reasonableness of P_i and P_a readings using *Sensor data* menu while ventilation is occurring. 4. Replace pressure solenoid PCB.
LOW INSP PRESSURE3 (diagnostic code 6025)	High-priority alarm. Technical alert. Cylinder pressure transducer reading (P_{cyl}) fell below -40 cmH_2O, possibly due to a patient outdrawing the ventilator's set flow rate. Alarm does not autoreset.	1. Make sure PEAK FLOW setting is adequate to meet patient's demand. Consider appropriate LOW INSP PRESSURE and ventilator settings. 2. Make sure air intake filter is not occluded. 3. Check reasonableness of P_{cyl} reading using *Sensor data* menu while ventilation is occurring. Perform a P_{cyl} gain equalization as required. 4. Replace pressure solenoid PCB.
LOW INT BATTERY (no diagnostic code logged)	HIgh-priority alarm. Low internal battery voltage detected during POST, although ac power is sufficient. Autoreset after 2 minutes. Once reset, alarm is not reannunciated.	1. Verify reliable ac power source. 2. Check internal battery connections. 3. Replace internal battery. 4. Replace BBU PCB.
LOW O2 SUPPLY (no diagnostic code logged)	High-priority alarm. Low oxygen supply pressure. Ventilation continues with reduced %O_2. (Alarm is not activated when %O_2 setting is 21%.) Autoreset when sufficient oxygen supply pressure is detected. The ventilator may have been calibrated at a high altitude then moved to a lower altitude.	1. Check patient. 2. Verify integrity of oxygen supply and connections. Increase oxygen supply pressure if necessary. 3. Perform these calibrations: O2 pressure calib, then (if applicable) Reg altitude calib (Section 4.2.3.2.2). 4. Replace oxygen regulator pressure transducer. 5. Replace pressure solenoid PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
LOW RESP RATE (*760* only, no diagnostic code logged)	Medium-priority alarm. The ventilator cannot deliver the current RESPIRATORY RATE setting (insufficient time for piston to retract and deliver next breath). Monitored respiratory rate lower than RESPIRATORY RATE setting by one breath per minute + 10% of the setting. Autoreset after 30 seconds. Pressing alarm reset key immediately disables the alarm and clears the autoreset, and the alarm is not reannunciated unless the condition perists after you change settings.	1. Check patient. 2. Check for ventilator breathing circuit disconnect or occlusion. 3. Consider appropriate RESPIRATORY RATE and other mandatory settings. 4. Consider adequacy of ventilatory support and patient comfort.
LOW SYS TEMP ALERT (diagnostic code 6009)	High-priority alarm. Technical alert. Temperature inside ventilator enclosure too low. Autoreset when temperature within range.	1. Make sure room temperature is not too low. Make sure that ventilator has warmed up and Tbox attained a steady state. 2. Replace pressure solenoid PCB.
MOTOR OVER TEMP (diagnostic code 6002)	High-priority alarm.Technical alert. Motor temperature too high. Autoreset when temperature within range (if within 2 minutes). Escalates to a 9008 condition (causing a ventilator reset) if temperature out of range longer than 2 minutes.	1. Check or replace main fan filter. 2. Check for proper operation of main fan. 3. Replace motor/encoder. 4. Replace controller PCB.
NEBULIZER FAILED (diagnostic code 6040)	Nebulizer failed alert. Power not being supplied to nebulizer.	1. Check cable connection between the communications panel and the nebulizer. 2. Replace cable. 3. Check cable connection between the communications PCB and the controller PCB. 4. Replace cable. 5. Replace communications PCB. 6. Replace nebulizer.
% O2 HIGH (no diagnostic code logged)	High-priority alarm. Measured oxygen percentage more than 10 percentage points above setting for at least 30 seconds. Autoreset when measured %O_2 is within 10 percentage points of setting.	1. Check air intake filter for occlusion. Replace if necessary. 2. Check oxygen supply. 3. Verify that an oxygen sensor is installed. 4. Check remaining sensor life (via service summary) and replace sensor if required. 5. Perform FIO_2 calibration check. 6. Replace pressure solenoid PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
% O2 LOW (no diagnostic code logged)	High-priority alarm. Measured oxygen percentage more than 10 percentage points below setting for at least 30 seconds. Autoreset when measured %O_2 is within 10 percentage points of setting. The ventilator may have been calibrated at a high altitude then moved to a lower altitude.	1. Check patient. 2. Check oxygen supply. 3. Verify that an oxygen sensor is installed. 4. Check remaining sensor life (via service summary) and replace sensor if required. 5. Perform FIO_2 calibration check. 6. Perform these calibrations: O2 pressure calib, then (if applicable) Reg altitude calib (Section 4.2.3.2.2). 7. Replace pressure solenoid PCB.
OCCLUSION (no diagnostic code logged)	High-priority alarm. Ventilator breathing circuit or inspiratory or expiratory filters occluded. Ventilator detects above-normal difference between inspiratory and expiratory pressure transducers. The ventilator enters occlusion cycling mode. Autoreset when the ventilator no longer detects an occlusion.	1. Check patient. 2. Check ventilator breathing circuit and inspiratory and expiratory filters for occlusions or kinks. Empty excess water from tubes. 3. Press the alarm reset key. 4. If this does not resolve the problem, provide alternate ventilation and contact service.
PARTIAL OCCLUSION (no diagnostic code logged)	High-priority alarm. Ventilator breathing circuit or inspiratory or expiratory filters occluded. Ventilator detects above-normal difference between inspiratory and expiratory pressure transducers. Safety valve remains closed, ventilation continues. Autoreset when ventilator fails to detect a partial occlusion for 2 consecutive breaths.	1. Check patient. 2. Check ventilator breathing circuit and inspiratory and expiratory filters for occlusions or kinks. Empty excess water from tubes. 3. Press the alarm reset key. 4. If this does not resolve the problem, provide alternate ventilation and contact service.
REPLACE O2 SENSOR (diagnostic code 6022)	High-priority alarm. Technical alert. Oxygen sensor missing or reading out of range. Alarm does not autoreset; you must press alarm reset key.	1. Make sure an oxygen sensor is installed and securely connected to ventilator head harness. 2. Perform FIO_2 calibration check. 3. Replace oxygen sensor.
SETUP TIME ELAPSED (no diagnostic code logged)	High-priority alarm. At least 30 seconds have elapsed since you pressed a key or turned the knob (occurs at power-on only). Autoreset when you accept proposed settings.	1. Check patient. Be sure to complete ventilator setup before connecting ventilator breathing circuit to patient. 2. Select appropriate ventilator settings.
SERVICE XDUCER (diagnostic code 6019)	High-priority alarm. Technical alert. Exhalation, cylinder, or flow sensor pressure transducer drift. Alarm does not autoreset.	1. Make sure that ventilator has warmed up sufficiently and is at a steady-state temperature. 2. Replace pressure solenoid PCB.

Table 7-2: Alarm messages (continued)

When you see this message:	It means...	Do this...
SPEAKER FAILED (diagnostic code 6007)	High-priority alarm. Technical alert. Main alarm speaker failed and backup alarm sounds. The ventilator continues to annunciate this alarm while the condition persists. Alarm does not autoreset; you must press alarm reset key.	1. Check wiring to speaker. 2. Replace speaker. 3. Replace pressure solenoid PCB.
SWITCH INT BATTERY (no diagnostic code logged)	Medium-priority alarm. Ventilator power source has switched to internal battery. Autoreset after 2 minutes, when ac power is restored, or when external battery is replaced.	1. Restore ac power, if possible. 2. Check external battery connections. 3. Replace external battery, if necessary. 4. Check LEDs on BBU PCB to determine presence of voltages. Replace BBU PCB, power supply, or power input component, as required.
VALVES TEST FAILED (diagnostic code 6039)	Safety valve stuck closed during POST	1. Check state of safety valve during POST. 2. If stuck closed, replace. 3. If safety valve open during POST, replace outlet check valve.

Service and repair

8.1 Introduction

8.1.1 How to use this section

This section describes how to repair the major ventilator subassemblies and their components. These repair procedures include removal, installation, and adjustment, as applicable. This section does not provide complete breakdowns of all assemblies and complete disassembly information. Repair procedures are provided mostly for major components. For a complete illustrated parts breakdown (IPB), refer to Section 9. Do not rely exclusively on Section 9 for removal and installation of parts.

8.1.2 General repair safety

- When servicing the ventilator, be sure to familiarize yourself with and adhere to all posted and stated safety warning and caution labels on the ventilator and its components, and on any service equipment and materials used. Failure to adhere to such warnings and cautions at all times may result in injury or property damage.
- To prevent patient injury, do not use a ventilator if it requires repair.
- To prevent personal injury or death, do not attempt any ventilator service while a patient or other person is connected to the ventilator.
- Use personal protective equipment whenever exposure to toxic fumes, vapor, dust particles, blood pathogens, and other transmittable diseases and hazardous material can be expected. If in doubt, consult an environmental, health, and safety specialist or an industrial hygienist before servicing the ventilator.
- To prevent electrical shock hazard and possible personal injury, always disconnect electrical power sources before servicing the ventilator. This means disconnecting not only mains power but also battery power from the BBU PCB. If the ventilator must be serviced with the power on, be careful to avoid electrical shock. Avoid reaching into the ventilator. Follow accepted safety practices for electrical equipment when testing or making equipment adjustments or repairs.
- To prevent possible personal injury, always disconnect oxygen source from the ventilator before service.
- To prevent possible personal injury, never attempt to push or pull a ventilator installed on a cart while the brakes are set on the casters.
- To prevent possible personal injury and equipment damage, make sure the brakes on the casters are set to prevent inadvertent movement of the ventilator during service.
- To prevent injury, never attempt to lift the ventilator without assistance. When lifting the ventilator, lift from the base, use assistance, and take appropriate safety precautions.

- To prevent equipment damage, pull, rather than push, the ventilator over high thresholds when using the cart to transport the ventilator. Ensure that the flex arm is positioned at the front of the ventilator.

8.1.3 General repair guidelines

Follow these general guidelines when servicing the ventilator:

- Adhere to general repair safety instructions at all times.
- Always use metric tools to remove metric fasteners. Using nonmetric tools to remove metric fasteners can damage fasteners.
- Use Phillips screwdrivers only to remove Phillips-head screws. Use POZIDRIV screwdrivers only to remove POZIDRIV screws. Interchanging screwdrivers may cause damage to screw heads.
- To prevent damage to electrostatic discharge (ESD) sensitive components, always follow ESD guidelines when servicing the ventilator. Adhere to ESD control techniques when repairing ESD-sensitive components.
- Use only recommended tools, test equipment, and service materials when servicing the ventilator (Section 1).
- Take precautions to prevent dirt and other particles from entering the ventilator interior, particularly the piston/cylinder assembly.
- As you repair the ventilator, perform any applicable cleaning and inspection procedures listed below.
- Visually inspect any removed ventilator parts, including those removed to gain access to a suspected faulty part. Inspect the exposed area behind the removed parts as well. Clean removed parts to facilitate further inspection as necessary.
- Investigate and determine the cause of any detected abnormality. Repair the unit or contact your regional Nellcor Puritan Bennett Technical Support for help in diagnosing unresolved symptoms.
- Replace or repair all parts that are worn, missing, damaged, cracked, corroded, burnt, warped, bent, disfigured, or broken. Consult Section 9 for parts availability.
- The repair sections assume that the patient system, flex arm, oxygen, and humidifier are already removed from the ventilator.
- When installing a new oxygen regulator, oxygen solenoid, pressure solenoid PCB, flow sensor, or piston/cylinder assembly, always (1) input the calibration constants for the new assembly into NVRAM (Section 4), and (2) affix the small calibration constants label provided on top of the larger calibration constants label inside the lid.

8.1.4 Repair-related cleaning

If needed, follow these general guidelines when cleaning the ventilator during servicing. Procedures for periodic cleaning and sterilization of the ventilator and accessories are given in the *700 Series Ventilator System Operator's Manual*. Specific procedures for periodic cleaning and inspection done during the ventilator's performance verification are given in Section 5 of this manual.

- Clean ventilator exterior surfaces before disassembly. Use isopropyl alcohol, a bactericidal agent, or a mild detergent and warm water solution, and a clean, lint-free cotton rag. Allow cleaned ventilator parts and surfaces to air-dry. The use of solvents and harsh cleaning detergents is not recommended.
- Vacuum ventilator interior using ESD-safe equipment. Do not clean ventilator interior with high-pressure air.
- During disassembly, clean parts as necessary with isopropyl alcohol. Replace any parts that cannot be cleaned.

8.1.5 Electrical cables and pneumatic tubing

- To ensure proper reassembly, note or label wire or tube positions before disconnecting parts.
- When pulling silicone tubes off fittings, pull gently while turning to avoid shredding the tubing.
- Make sure all tubes and harnesses or cables are reinstalled using cable ties, as specified. Make sure wiring does not interfere with and cannot be damaged by hinged or moving ventilator parts. Make sure that the grounding harness is replaced to the oxygen regulator.

8.1.6 Adhesive use

- When installing a part to be attached with adhesive, first remove the adhesive residue using a suitable scraping tool that won't scratch the ventilator surface. Clean scraped surfaces thoroughly with isopropyl alcohol. Be sure the application area is free of dust and grease, then press on item, ensuring adhesive contact and bonding. Eliminate any trapped air bubbles.
- Be careful when using any cleaners and solvents, as these may cause personal injury or damage to ventilator surfaces. Use in a well ventilated area.
- Replace any damaged warning and caution labels using the removal and installation techniques described above.

Warning

The failure to replace damaged warning, caution, and identification labels may result in personal injury, equipment, or property damage.

8.1.7 Electrostatic discharge control

It is important to follow ESD control procedures whenever the ventilator is repaired.

8.1.7.1 General information

ESD can permanently damage ESD-sensitive microelectronic components or assemblies when they are handled and even when no direct contact is made with the component or assembly. ESD damage may not be immediately detectable; however, ESD damage will show up at a later time, either as a premature catastrophic failure of a component or assembly, or as an intermittent failure, which can be difficult and costly to locate.

The following static-shielding bags are available to store *700 Series Ventilator System* components:

Part number	Description
G-061534-00	Electrostatic-shielding bag, 66 x 46 cm (26 x 18 in.), for UI display PCB
G-061533-00	Electrostatic-shielding bag, 28 x 38 cm (11 x 15 in.), for controller PCB, BBU PCB, or pressure solenoid PCB
G-061532-00	Electrostatic-shielding bag, 13 x 20 cm (5 x 8 in.), for optoswitch

8.1.7.2 Procedures and precautions

Follow these procedures and precautions to prevent ESD damage to the ESD-sensitive microelectronic components and assemblies of the *700 Series* Ventilators.

- **Use a personnel grounding system.** Before opening the ventilator lid or removing its cabinet panels, ensure that a personnel grounding system such as Nellcor Puritan Bennett P/N G-061661-00 (wrist strap, static-dissipative mat, and ground cord) is worn correctly and is properly connected to a reliable ground.
- **Follow correct procedures for use of static-dissipative mat.** Place tools, test equipment and the ESD-sensitive device on the mat before starting repairs. Conduct all work from the mat. Never place nonconductive items (for example, foam cups) on the mat.
- **Handle ESD-sensitive components properly.** Do not handle ESD-sensitive component connection points, connector pins, leads, or terminals.
- **Keep nonconductive materials away from work area.** Static charges from nonconductive material (plastic containers, foam cups, synthetic clothing, cellophane tape, etc.) cannot be removed by grounding. These items must be kept away from the work area when handling ESD-sensitive devices.
- **Follow correct procedures for use of static-shielding bags.** Store and transport all ESD-sensitive devices in static-shielding bags at all times except when being worked on. Never place more than one ESD-sensitive device in a static-shielding bag. Never place static-generating nonconductive material inside a static-shielding bag with an ESD-sensitive device. Place any faulty ESD-sensitive device in a static-shielding bag immediately after removal to prevent additional damage. Close the bag to ensure that shield is effective.

8.1.8 Repainting and touch-up

Before repainting or touching up the ventilator, smooth out the area with a fine sandpaper, and make sure it is free from any grease, corrosion, or dust. Remove the part to be painted or mask off the surrounding area to prevent overspray or spills.

Use the following touch-up paints for the ventilator:

- Charcoal liquid lacquer (P/N G-062000-00), for the ventilator lid
- Gray liquid lacquer (P/N G-061361-00), for the ventilator cart
- White liquid lacquer (P/N G-061999-00), for the ventilator cabinet

8.1.9 Replacement part ordering

To order correct parts, identify the ventilator version and part, then use Section 9 to locate it. To replace a part that is not stocked or that is unavailable, order the next higher assembly. Retain the part to be replaced until the replacement part is obtained, and compare the two for compatibility, if possible.

8.1.10 Post-repair

After you complete any ventilator repair, do the following:

- Visually verify that all pneumatic and electrical parts are properly connected and that all parts are properly installed. Then, with a light tug, verify that connections are secure and that parts are securely attached. Listen for any uncharacteristic sounds (pneumatic leaking, vibrations, grinding, squeaking, or others). Be sure the piston, fans, pump, panel hinges, and casters move freely. Check for any unusual odors.
- Run indicated portions of the performance verification (see Table 5-1) before placing the ventilator on a patient.
- Keep a maintenance log of all repairs. Make sure service records and other documentation are completed.

8.2 Patient system and accessories

For maintenance of the patient system and accessories, consult the *700 Series Ventilator System Operator's Manual* or applicable accessory manuals.

Warning

Connectors and tubes with the proprietary Bennett barbed cuff fittings are intended for use only with like fittings. They are not interchangeable with ISO-standard cone and socket fittings. A leaktight connection cannot be ensured if these two fitting types are combined. Adapters may be used to connect Bennett barbed cuff fittings to ISO-standard cone and socket fittings.

8.3 Cart assembly

Warning

- To prevent equipment damage, pull, rather than push, the ventilator over high thresholds when using the cart to transport the ventilator. Ensure that the flex arm is positioned at the front of the ventilator.
- To prevent possible personal injury, never attempt to lift the ventilator without assistance. When lifting the ventilator, lift from the base, use assistance, and take appropriate safety precautions.

8.3.1 Removing/installing ventilator from/to cart

Remove the ventilator from the cart as follows. Install by reversing removal procedure.

1. Make sure brakes on cart are engaged.
2. Using 5-mm hex driver, remove two M6 x 16 screws, flat washers, and external lockwashers from side of cart (Figure 8-1).
3. With another person holding ventilator (to prevent it from toppling), push ventilator away from side of cart where screws were, until ventilator's L-shaped interlocking rails slide clear of slots in cart (approximately $^1/_8$ in.) (Figure 8-2).
4. Lift ventilator straight up off cart.

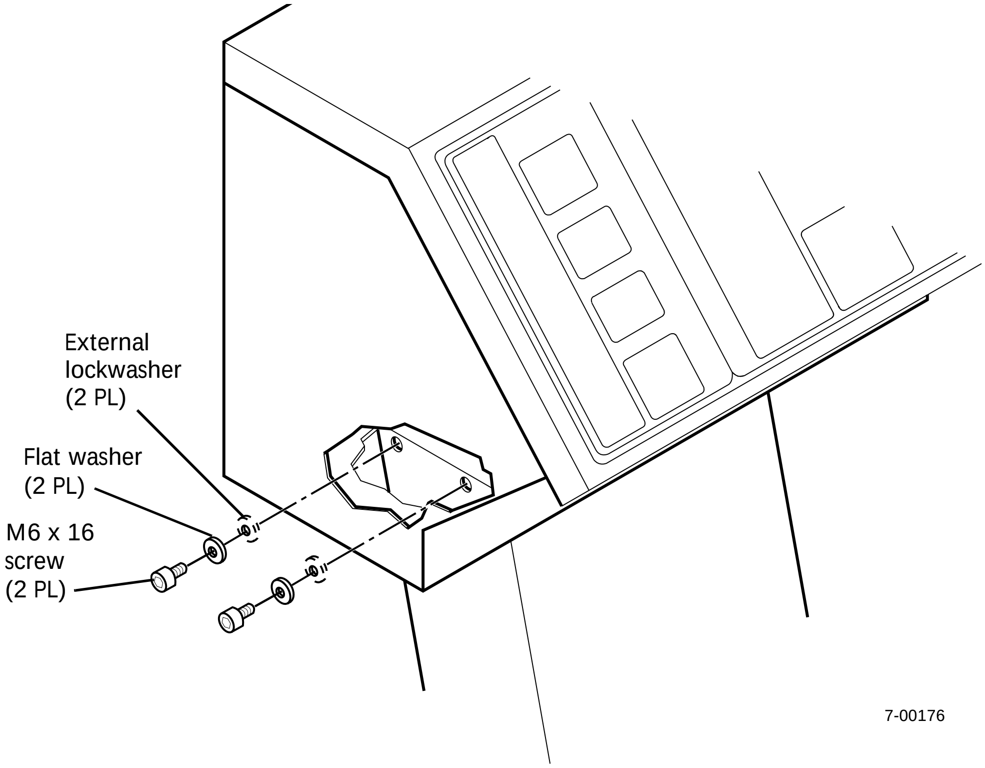


Figure 8-1. Removing ventilator attachment screws from cart

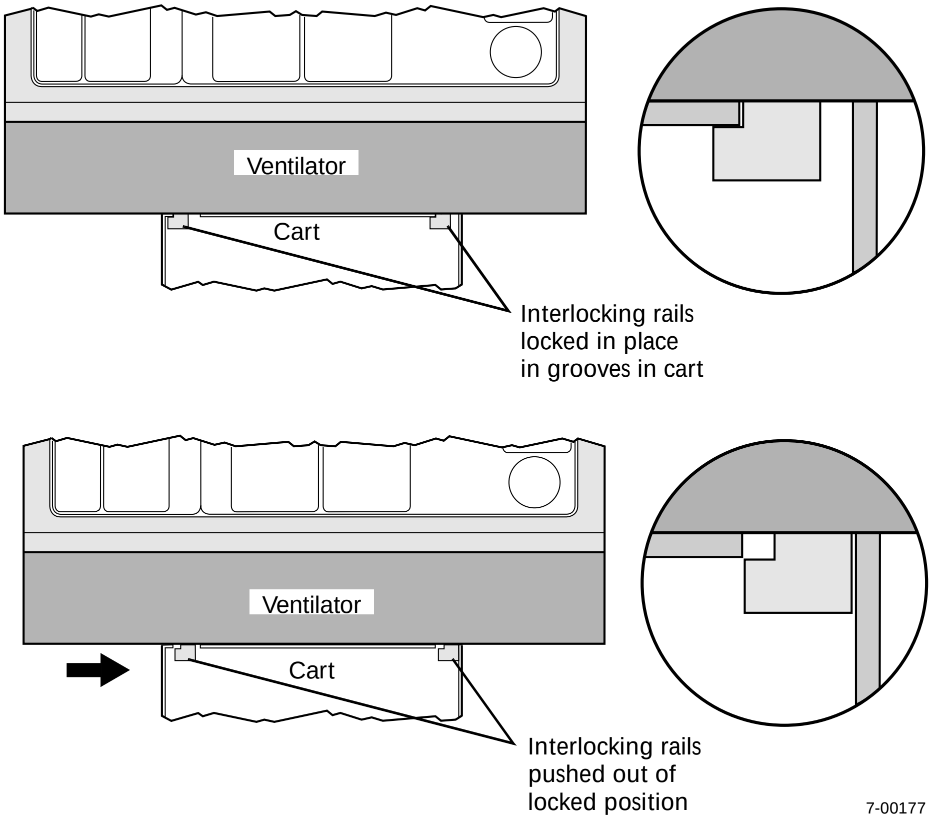

Ventilator
Cart
Interlocking rails locked in place in grooves in cart
Ventilator
Cart
Interlocking rails pushed out of locked position
7-00177

Figure 8-2. Removing ventilator from cart

8.3.2 Removing/installing oxygen cylinder brackets (Figure 8-3)

Remove the oxygen cylinder brackets from the cart as follows. Install by reversing removal procedure.

1. Loosen cylinder-retaining wing screws. Lift out cylinders.
2. Using 7-mm nutdriver, remove four M4 nuts with captive lockwashers that retain each of two lower cylinder supports. Remove supports.
3. Using 5-mm hex driver, remove two M6 x 16 screws, flat washers, and split-ring washers that retain each of two upper cylinder brackets. Remove brackets.

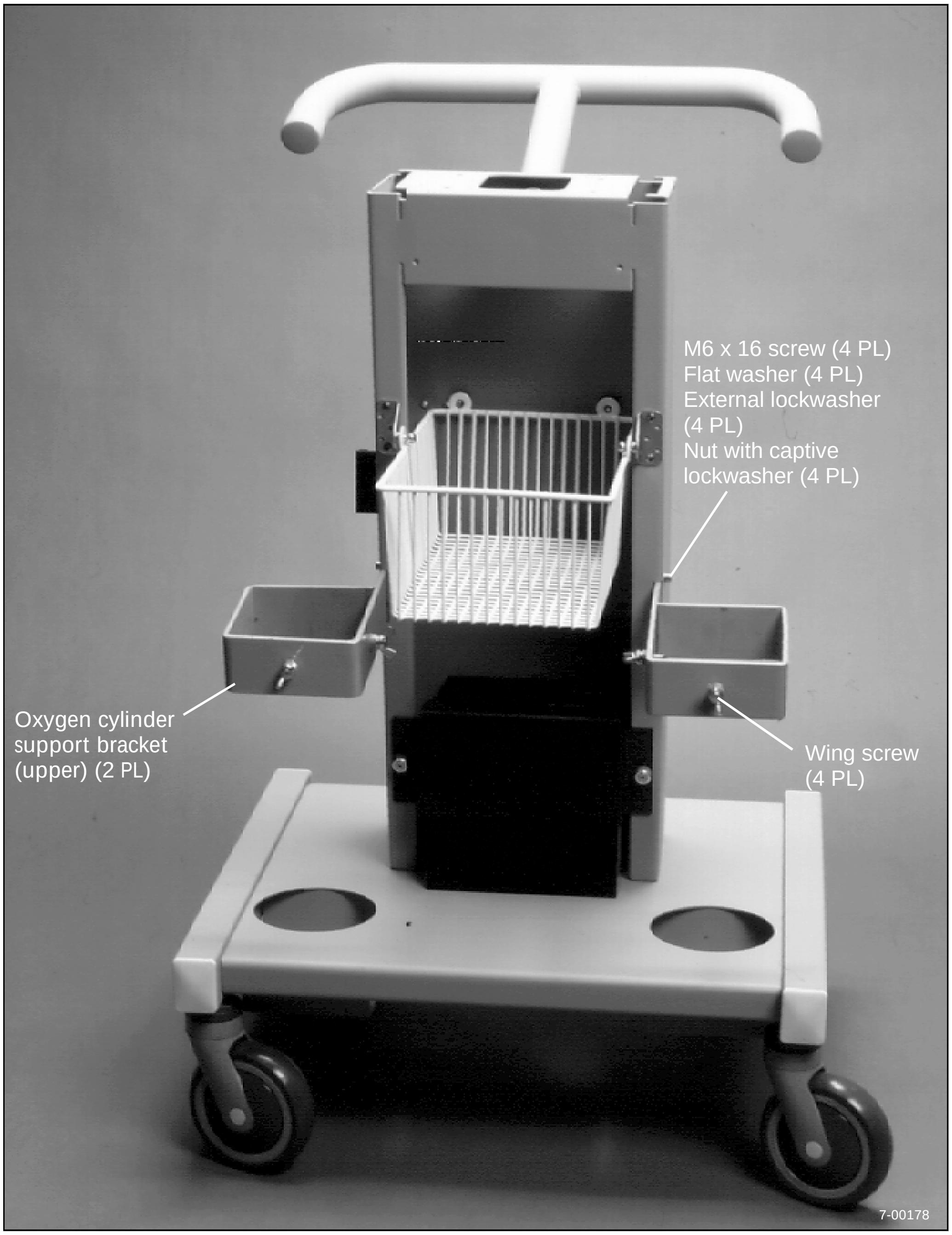

M6 x 16 screw (4 PL)
Flat washer (4 PL)
External lockwasher (4 PL)
Nut with captive lockwasher (4 PL)
Oxygen cylinder support bracket (upper) (2 PL)
Wing screw (4 PL)
7-00178

Figure 8-3. Removing oxygen cylinder brackets

8.3.3 Removing/installing cylinder covers

Using 7-mm nutdriver, remove four nuts with captive lockwashers that retain each cylinder cover. Install by reversing removal procedure.

8.3.4 Removing/installing collector vial support bracket (Figure 8-4)

Using 3-mm hex driver, remove two M4 x 8 screws, flat washers, and split-ring washers that retain bracket to cart. Remove bracket. Install by reversing removal procedure.

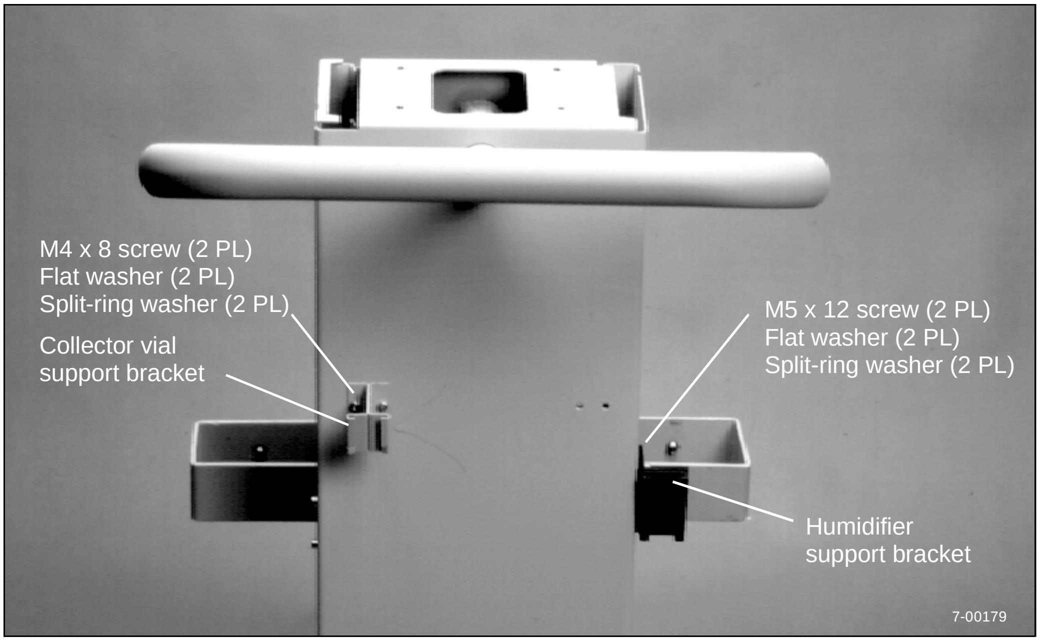

M4 x 8 screw (2 PL)
Flat washer (2 PL)
Split-ring washer (2 PL)
Collector vial support bracket
M5 x 12 screw (2 PL)
Flat washer (2 PL)
Split-ring washer (2 PL)
Humidifier support bracket
7-00179

Figure 8-4. Removing collector vial and Fisher & Paykel Humidifier support brackets from cart

8.3.5 Removing/installing humidifier support bracket

8.3.5.1 Fisher & Paykel humidifier support bracket (Figure 8-4)

Using 4-mm hex driver, remove two M5 screws, flat washers, and split-ring washers that retain bracket to cart. Remove bracket. Install by reversing removal procedure.

8.3.5.2 Hudson RCI humidifier support bracket assembly (Figure 8-5)

Remove two M6 x 20 screws, split-ring washers, and flat washers that retain bracket assembly to cart. Remove bracket. Disassemble bracket assembly as required. Install by reversing removal procedure.

8.3.6 Removing/installing basket (Figure 8-6)

Partially remove screw retaining one of two basket-retaining ball brackets. Slip basket off studs on ball brackets and studs on inside of column. Install by reversing removal procedure.

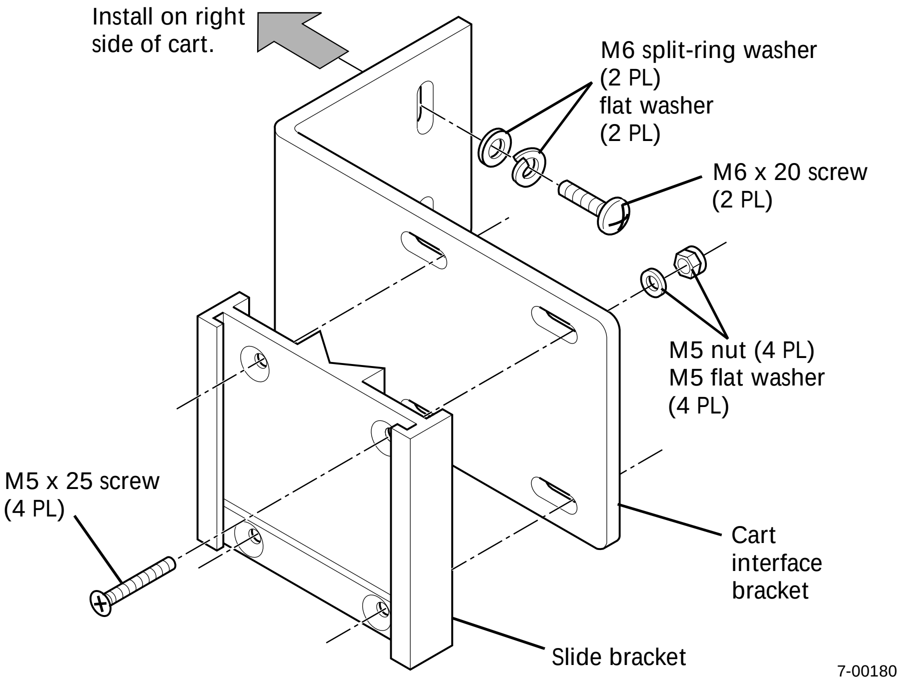

Install on right side of cart.
M6 split-ring washer (2 PL)
flat washer (2 PL)
M6 x 20 screw (2 PL)
M5 nut (4 PL)
M5 flat washer (4 PL)
M5 x 25 screw (4 PL)
Cart interface bracket
Slide bracket
7-00180

Figure 8-5. Removing Hudson RCI humidifier bracket assembly

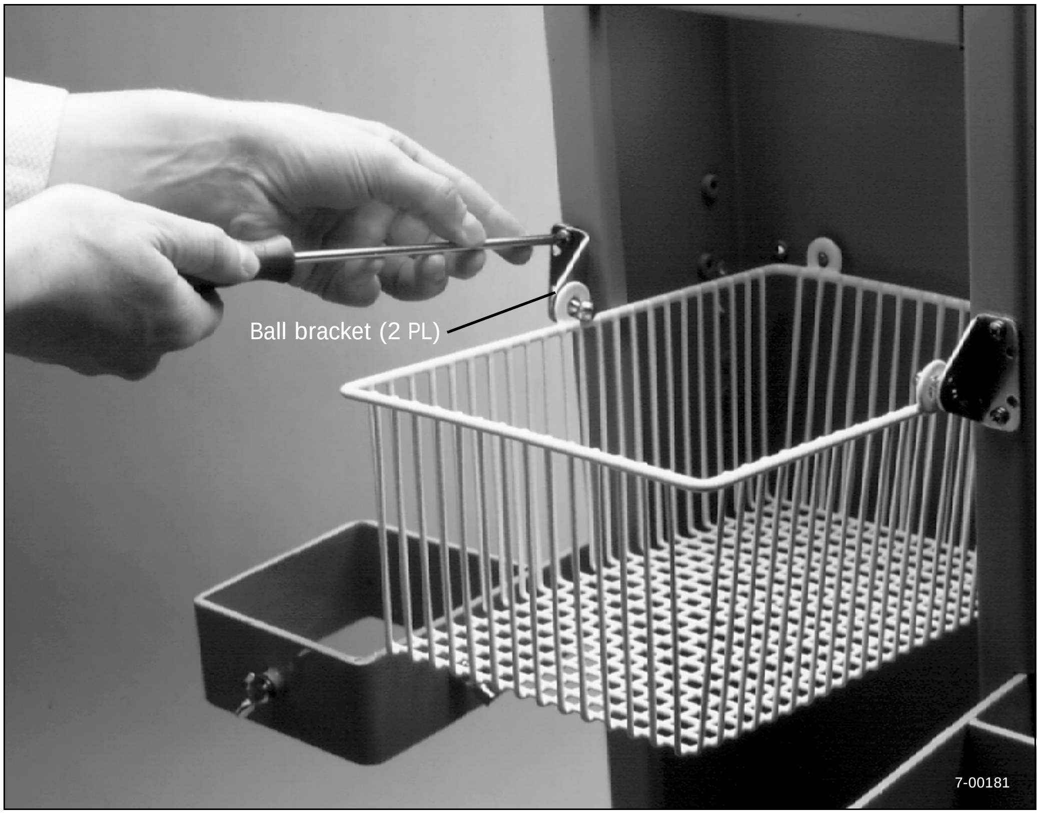

Ball bracket (2 PL)
7-00181

Figure 8-6. Removing basket

8.3.7 Removing/installing external battery and cover (Figure 8-7)

Remove the external battery and cover from the ventilator as follows. Install by reversing removal procedure.

1. Disconnect battery from external battery connector at rear of ventilator.
2. Loosen two captive thumbscrews that retain external battery cover. Remove cover.
3. Remove battery.

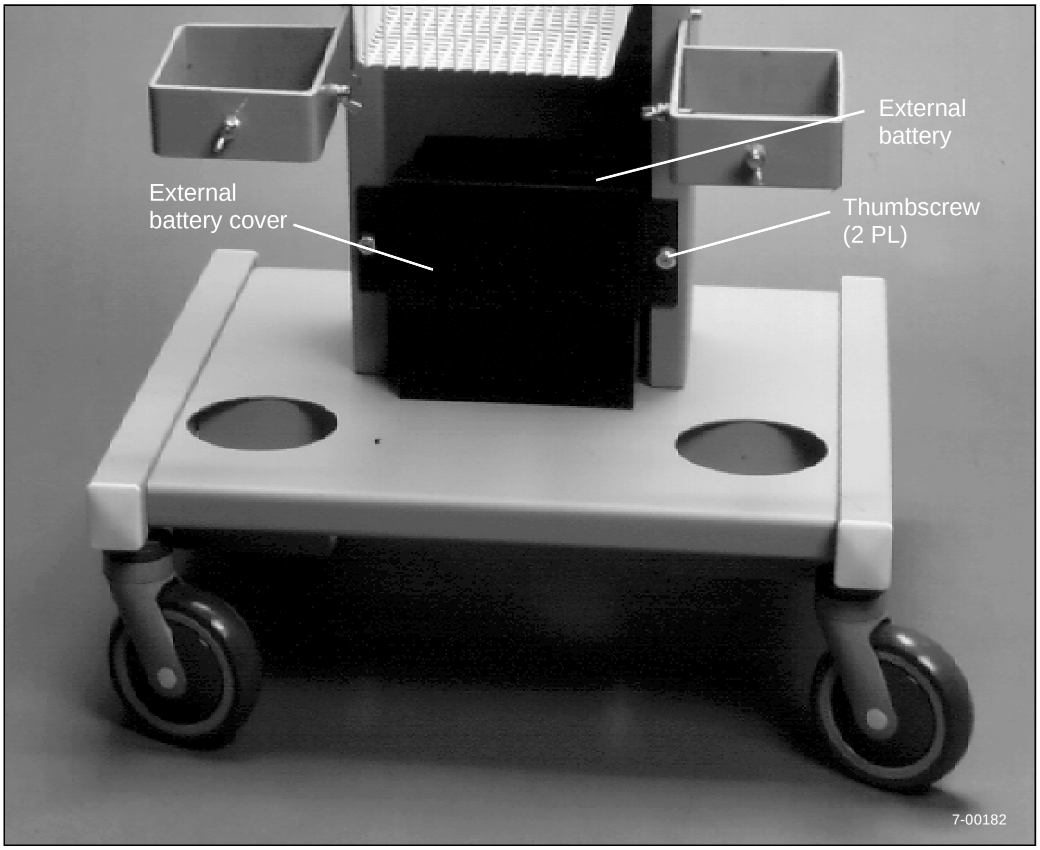

External battery
External battery cover
Thumbscrew (2 PL)
7-00182

Figure 8-7. Removing external battery cover

8.4 Shelf mount

Warning

To prevent possible personal injury, never attempt to lift the ventilator without assistance. When lifting the ventilator, lift from the base, use assistance, and take appropriate safety precautions.

8.4.1 Removing/installing ventilator from/to shelf mount

Remove the ventilator from the shelf mount as follows. Install by reversing removal procedure.

1. Using 4-mm hex driver, remove M5 x 8 screw, flat washer, and split-ring washer that attach shelf mount to ventilator (Figure 8-8).
2. While facing ventilator, slide ventilator to your right until interlocking rails clear slots on shelf mount bracket (Figure 8-9).

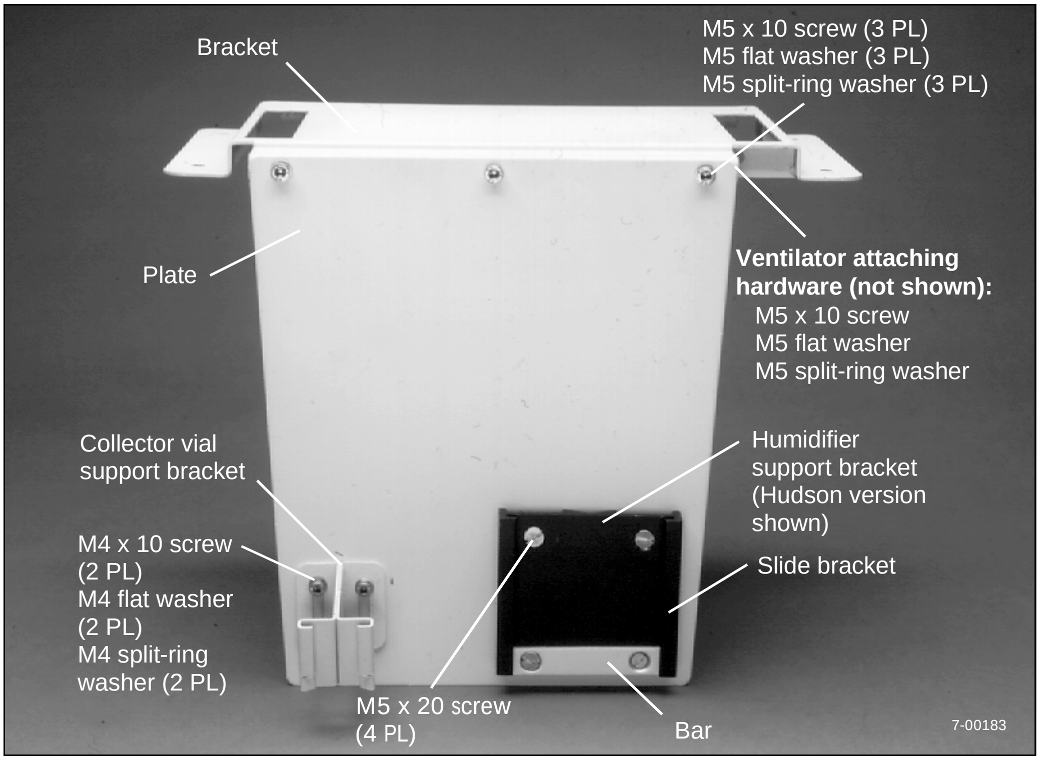

Bracket
M5 x 10 screw (3 PL)
M5 flat washer (3 PL)
M5 split-ring washer (3 PL)
Plate
Ventilator attaching hardware (not shown):
M5 x 10 screw
M5 flat washer
M5 split-ring washer
Collector vial support bracket
Humidifier support bracket (Hudson version shown)
M4 x 10 screw (2 PL)
M4 flat washer (2 PL)
M4 split-ring washer (2 PL)
Slide bracket
M5 x 20 screw (4 PL)
Bar
7-00183

Figure 8-8. Removing collector vial and humidifier support brackets from shelf mount

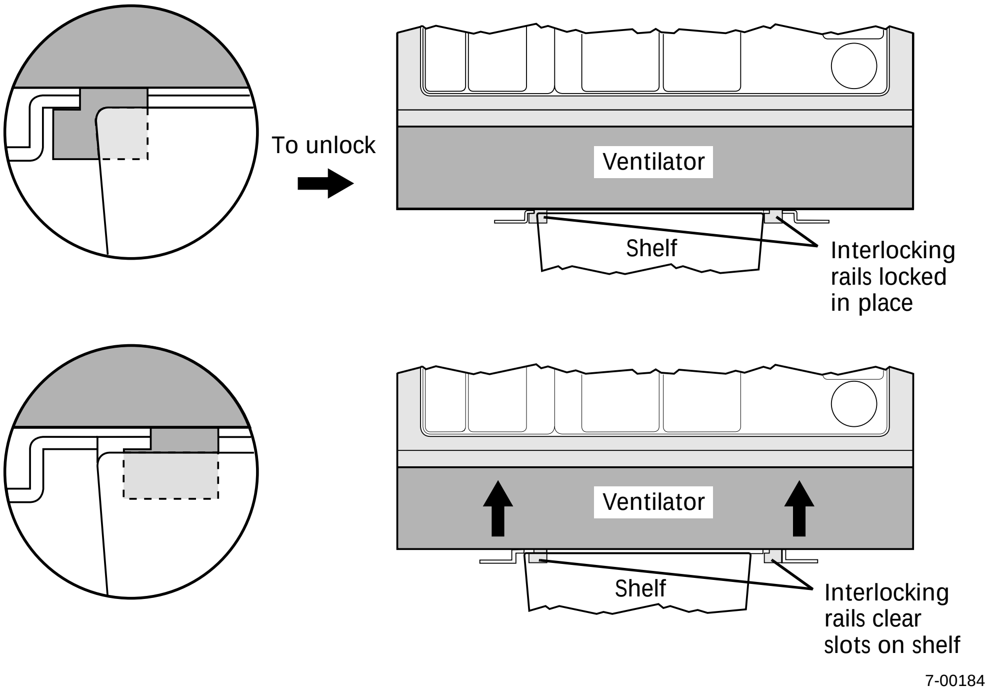

To unlock
Ventilator
Shelf
Interlocking
rails locked
in place
Ventilator
Shelf
Interlocking
rails clear
slots on shelf
7-00184

Figure 8-9. Removing shelf mount from ventilator

8.4.2 Removing/installing collector vial support bracket (Figure 8-8)

Using 3-mm hex driver, remove two M4 x 10 screws, flat washers, and split-ring washers that retain support bracket to shelf mount plate. Remove support bracket. Install by reversing removal procedure.

8.4.3 Removing/installing humidifier support bracket (Figure 8-8)

Remove two M5 x 10 flat-head screws (Fisher & Paykel bracket) or four M5 x 20 flat-head screws (Hudson RCI bracket) that retain support bracket to shelf mount plate. Remove bracket. Install by reversing removal procedure.

8.5 User interface (UI) assembly (lid)

8.5.1 Opening and propping lid

1. Using 3-mm hex driver, loosen M4 x 12 screws on latch-retaining brackets (Figure 8-10). Swing brackets aside, and open latches.
2. Lift lid, then prop it up by tightening thumbscrew near center of lid hinge (Figure 8-11).

8.5.2 Removing/installing lid

Remove the lid from the ventilator, as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect UI/ventilator head cable from controller PCB (Figure 8-10).
3. Using 8-mm nutdriver, remove M5 nut, flat washer, and internal lockwasher that retain ground wire. Detach ground wire from lid.
4. Unprop lid by loosening thumbscrew.
5. Remove lid by pulling plunger on rear wall of cabinet assembly while sliding lid to right.

Caution

- To prevent damage to the lid, take care to prevent it from falling off during removal. Do not hold the lid assembly by grabbing on to the UI display PCB.
- To avoid damaging the keyboard, do not press on it with sharp objects and place it on clean work surface free of debris.

6. To service lid, place it upside-down on clean work surface free of debris. Support lid to prevent damage to knob/encoder.

Caution

To prevent damage to ESD-sensitive components, always follow ESD guidelines when servicing the lid.

NOTE:

When installing a new lid, transfer tension clips and attaching nuts from original to new lid.

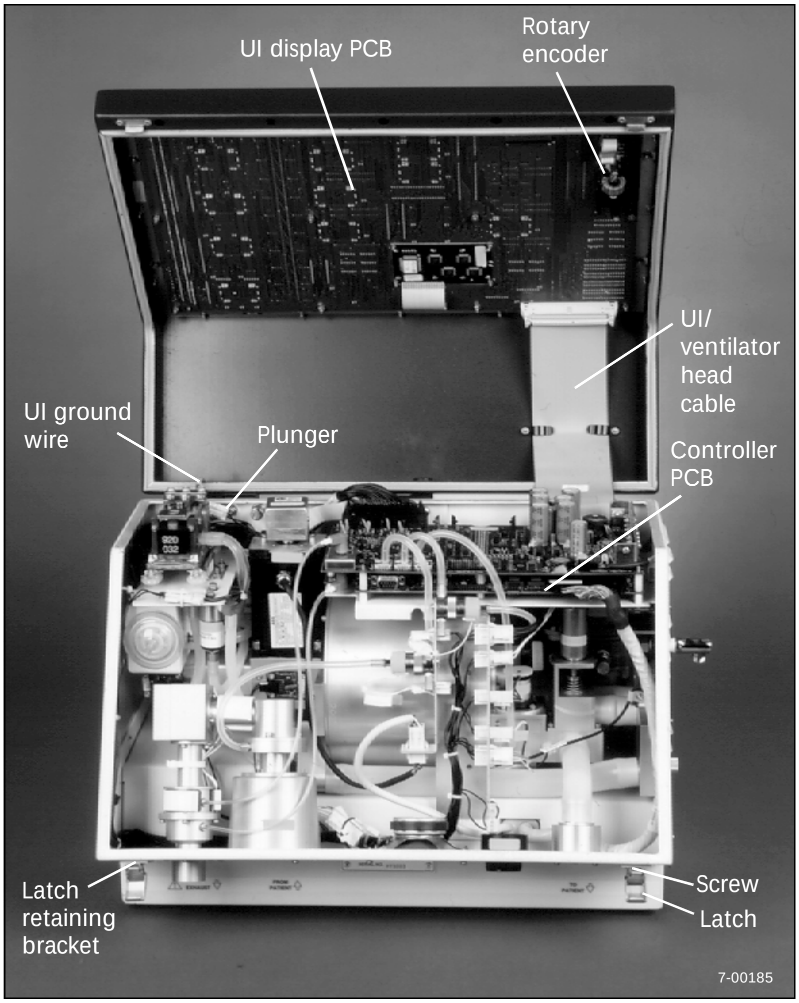

UI display PCB
Rotary encoder
UI/ ventilator head cable
UI ground wire
Plunger
Controller PCB
Latch retaining bracket
Screw
Latch
7-00185

Figure 8-10. Lid raised

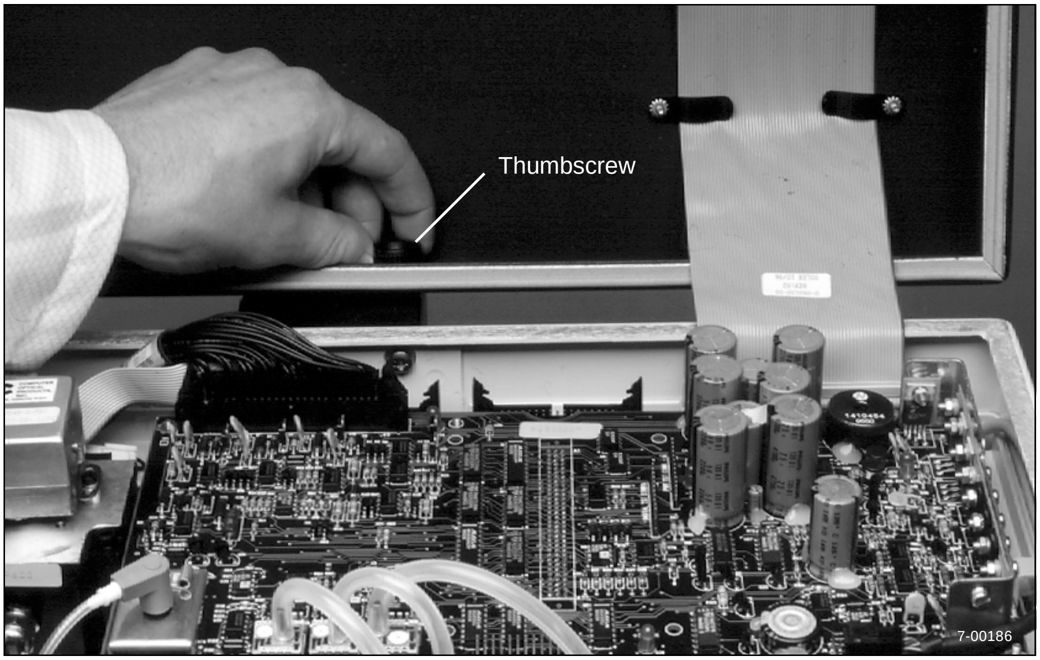


Figure 8-11. Propping the lid

8.5.3 Knob and rotary encoder (Figure 8-12)

Remove the knob and rotary encoder as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Using 1/16-in. hex driver, loosen setscrew in knob. Remove knob.
3. Using 11-mm nutdriver or wrench, remove nut and internal lockwasher from switch shaft.
4. Disconnect rotary encoder cable from UI display PCB.
5. Pull out rotary encoder.

NOTE:

When removing the rotary encoder, be careful not to lose the nylon spacer installed beneath the UI.

8.5.4 UI display PCB (Figure 8-12)

Caution

When disassembling the UI, account for all fasteners removed, as fasteners falling between the keyboard and the UI display PCB may cause equipment failure.

Remove the UI display PCB as follows. Install by reversing removal procedure.

1. Remove lid (Section 8.5.2).
2. Disconnect rotary encoder cable.
3. Remove LCD panel (Section 8.5.5).
4. Disconnect UI and keyboard cables.
5. Using 7-mm nutdriver, remove 12 M4 nuts and external lockwashers. Lift out PCB.

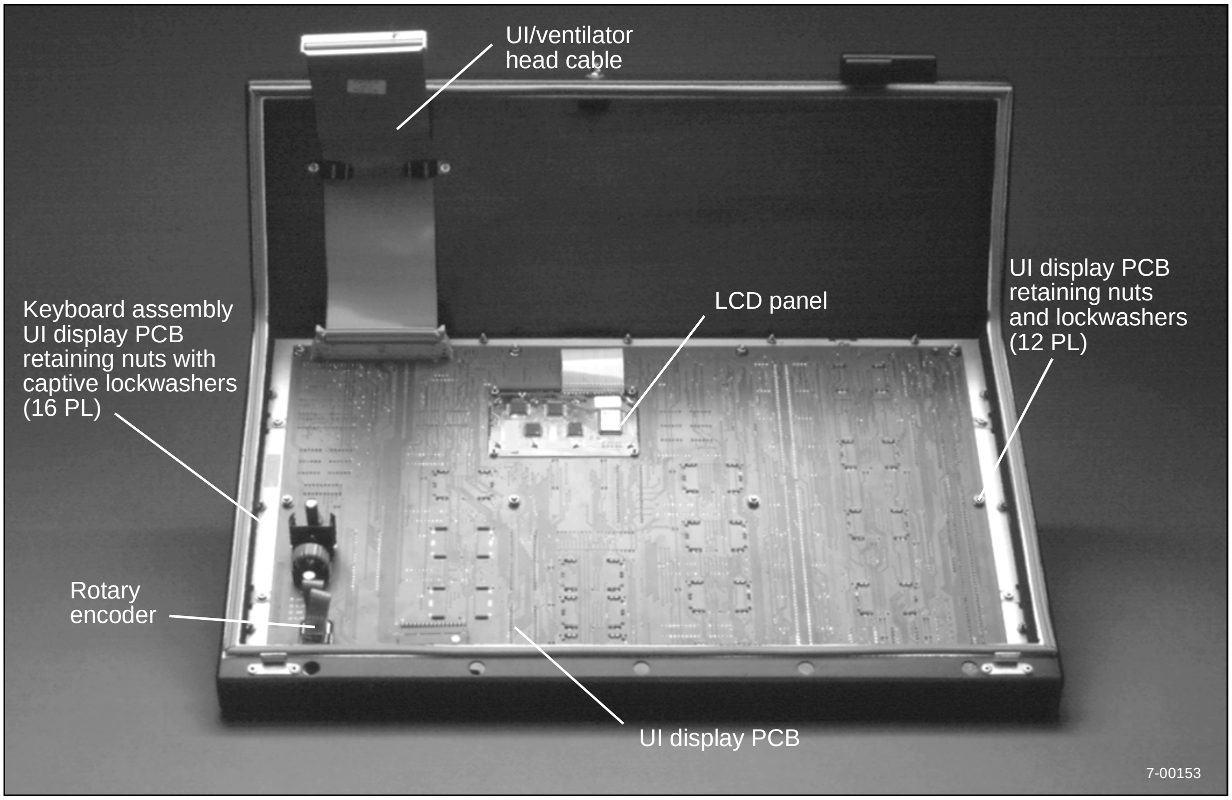

UI/ventilator head cable
LCD panel
UI display PCB retaining nuts and lockwashers (12 PL)
Keyboard assembly UI display PCB retaining nuts with captive lockwashers (16 PL)
Rotary encoder
UI display PCB
7-00153

Figure 8-12. UI removed

8.5.5 LCD panel (message window)

Caution

When disassembling the UI, account for all fasteners removed, as fasteners falling between the keyboard and the UI display PCB may cause equipment failure.

Remove the LCD panel as follows. Install by reversing removal procedure.

1. Remove lid (Section 8.5.2).
2. Using 5-mm nutdriver, remove four M2.5 nuts, internal lockwashers, and fiber washers that attach LCD panel to UI display PCB. Remove LCD panel (Figure 8-13).
3. Detach LCD panel ribbon cable from UI display PCB (Figure 8-12).

NOTE:

When installing the LCD panel, be sure ribbon cable is at top of panel.

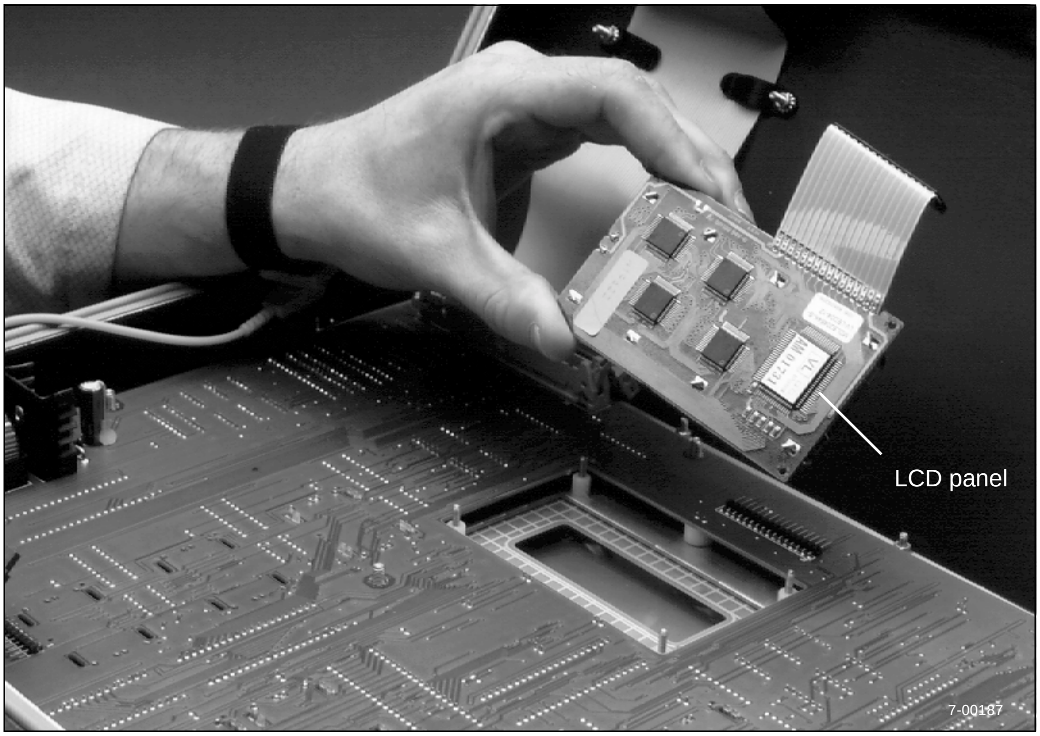


Figure 8-13. Removing LCD panel

8.5.6 Keyboard assembly

Caution

When disassembling the UI, account for all fasteners removed, as fasteners falling between the keyboard and the UI display PCB may cause equipment failure.

Remove the keyboard assembly as follows. Install by reversing removal procedure.

1. Remove LCD panel (Section 8.5.5).
2. Disconnect UI/ventilator head cable from UI display PCB.
3. Using 5.5-mm or $^{7}/_{32}$-in. nutdriver, remove 16 M3 nuts with captive external lockwashers that attach keyboard assembly/UI display PCB to lid (Figure 8-12). Lift out assembly.
4. Separate keyboard assembly from UI display PCB:
    a. Using 7-mm nutdriver, remove 12 M4 nuts and external lockwashers.
    b. Disconnect cables (keyboard and rotary encoder) from UI display PCB. Separate PCB from keyboard.
5. If you are installing a new keyboard assembly, unscrew and transfer 16 nylon spacers from original keyboard assembly to new keyboard assembly (Figure 8-14).

NOTE:

When installing the keyboard assembly to the lid, make sure the keyboard is oriented with the bar graph to your right. Do not overtighten the nuts. Inspect the UI panel windows for smudges or debris. Clean as required using UI cleaning spray (P/N G-061576-00).

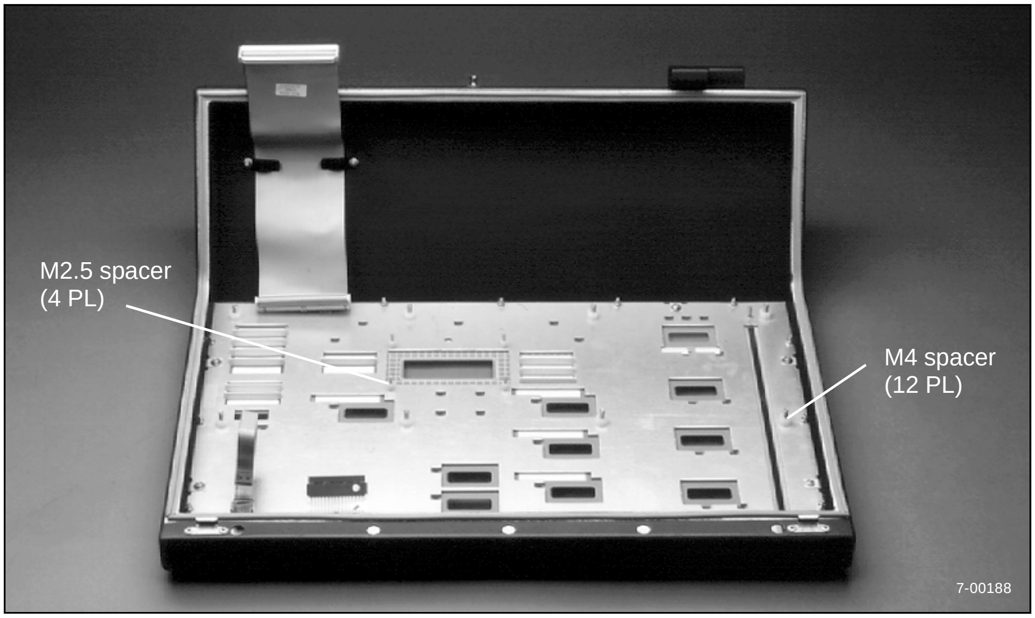


Figure 8-14. Spacers on keyboard assembly

8.6 Ventilator head cabinet assembly

8.6.1 Oxygen adapter assembly

To remove the oxygen adapter assembly (if ventilator is so equipped), unscrew it from the ventilator's standard male DISS fitting. The oxygen adapter assembly can also be disassembled (as required) while it is on or off the ventilator (Figure 8-15).

To install the oxygen adapter assembly, remove any existing PTFE tape from the ventilator's DISS male fitting and apply new tape (P/N G-060759-00). Screw adapter assembly onto DISS fitting. Leak-test by applying leak test fluid (P/N 4-004489-00) with a suitable small brush to all connections between where the hose attaches and the male DISS fitting inlet. If new bubbles form, repair the leak. Use a clean cloth to remove the leak detector.

NOTE:

- When assembling oxygen adapters, use PTFE tape as shown in Figure 8-15. On the Australian fitting, use PTFE tape on all threads of the male DISS fitting and on the threaded male adapter. PTFE tape is not required on the male DISS fitting if you are using a DISS female hose (USA) or a Dräger hose.
- To prevent tape debris from coming loose and entering the pneumatic system, do not wrap tape around the first two threads.

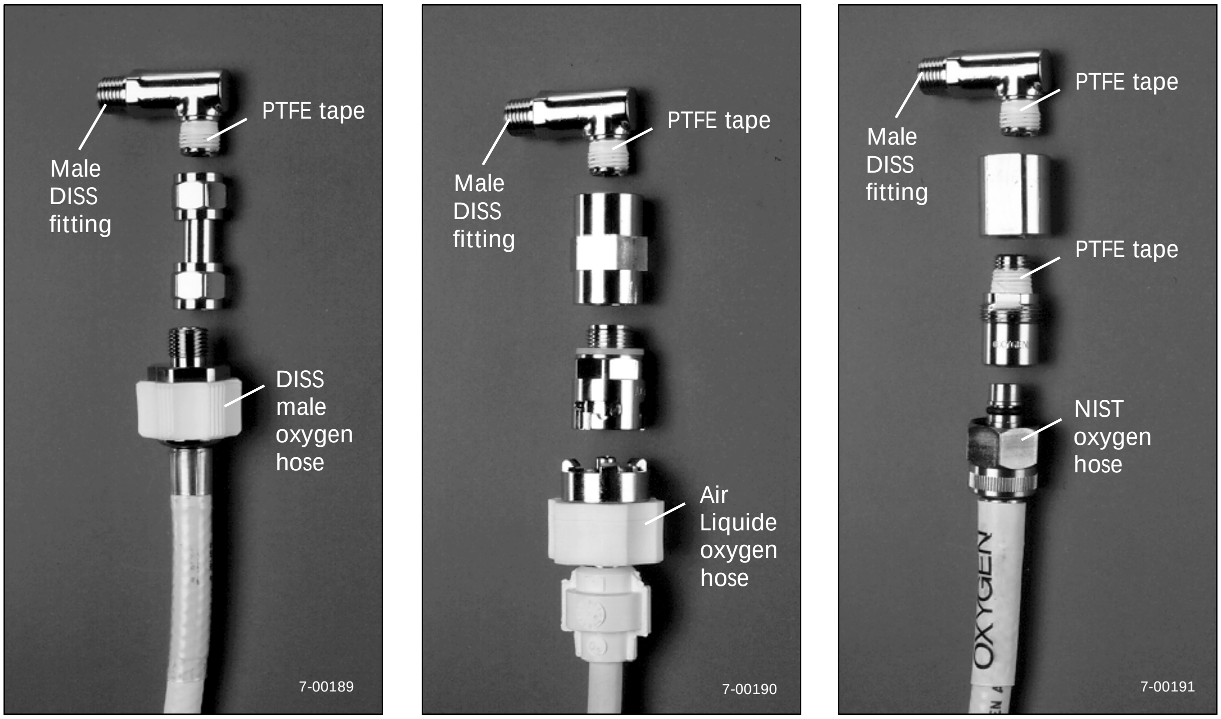

PTFE tape
Male DISS fitting
DISS male oxygen hose
7-00189
PTFE tape
Male DISS fitting
Air Liquide oxygen hose
7-00190
PTFE tape
Male DISS fitting
PTFE tape
NIST oxygen hose
OXYGEN
7-00191

Figure 8-15. Oxygen adapter assemblies disassembled

8.6.2 Options panel plate (Figure 8-16)

Remove options panel plate by removing seven M3 x 8 POZIDRIV screws with captive washers. Install by reversing removal procedure.

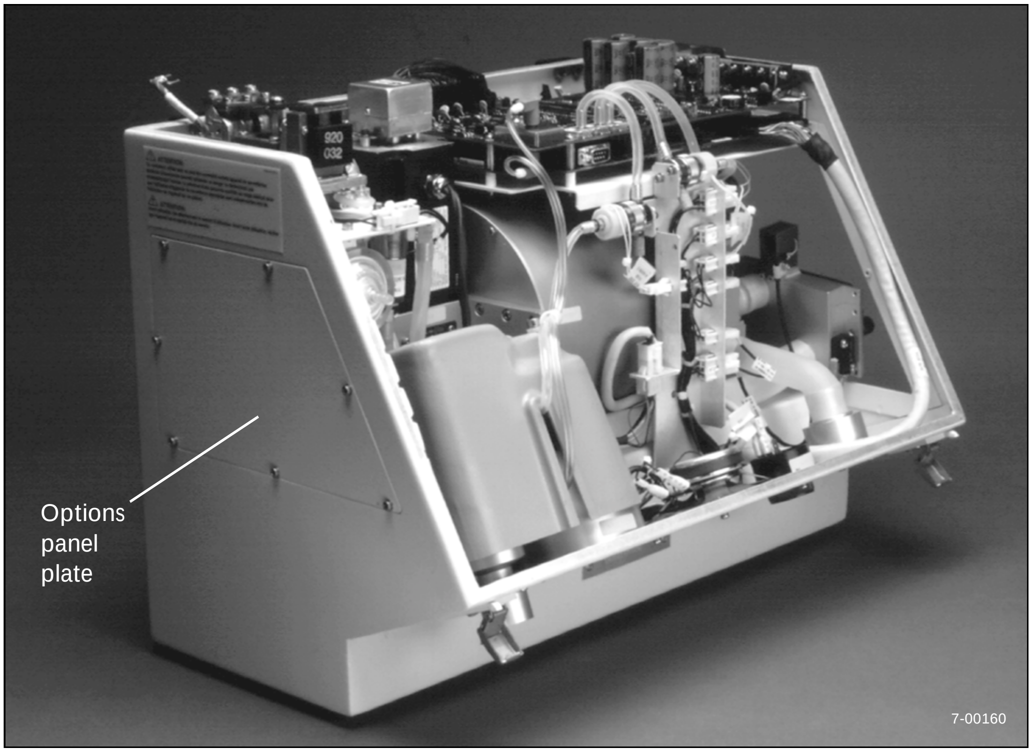
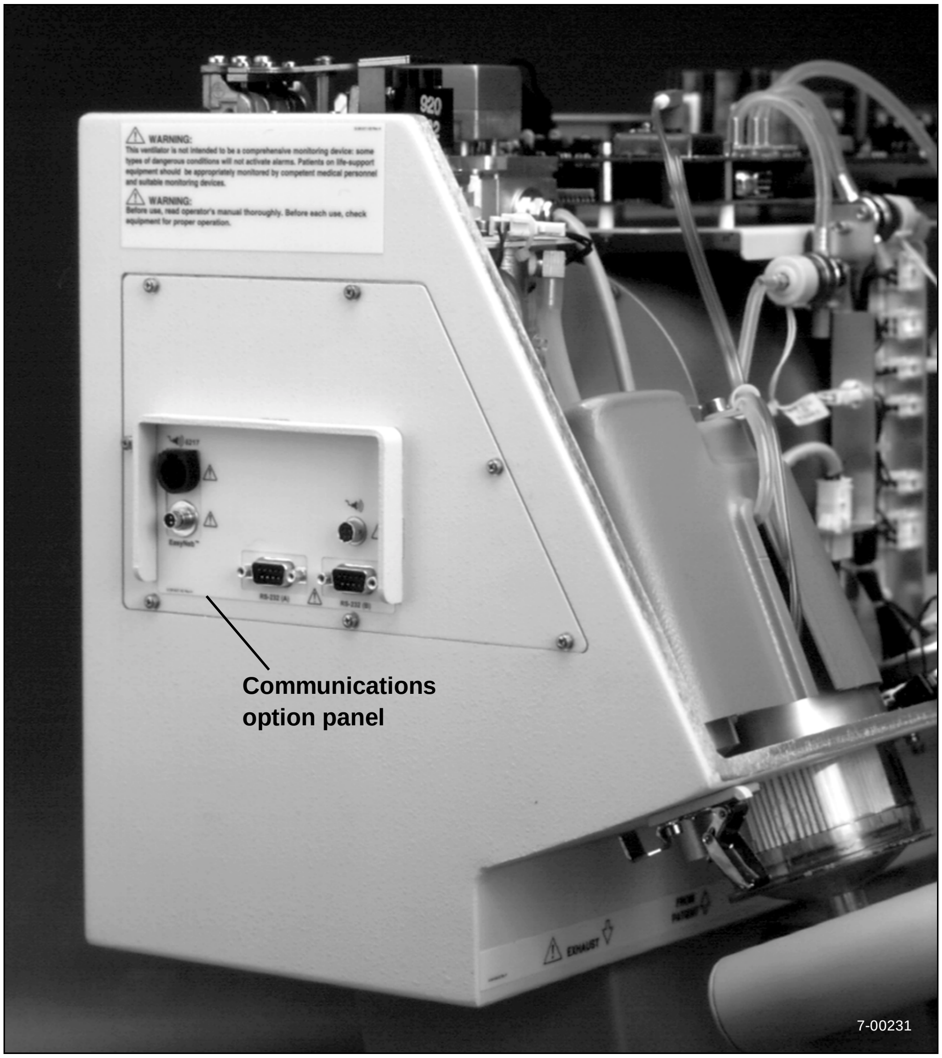


Figure 8-16. Options panel plate

8.6.3 Communications option (Figure 8-17)



WARNING:
This ventilator is not intended to be a comprehensive monitoring device: some types of dangerous conditions will not activate alarms. Patients on life-support equipment should be appropriately monitored by competent medical personnel and suitable monitoring devices.

WARNING:
Before use, read operator's manual thoroughly. Before each use, check equipment for proper operation.

Figure 8-17. ***700 Series*** **Communications option panel**

Remove the Communications option assembly as follows. Install by reversing removal procedure.

1. Open and prop the lid (Section 8.5.1)
2. Unscrew the seven M3 x 8 POZIDRIV screws from the Communications option panel (Figure 8-18), and pull the panel out to allow access to the Communications option assembly.
3. Remove the ribbon cable from its connector on the Communications option assembly.

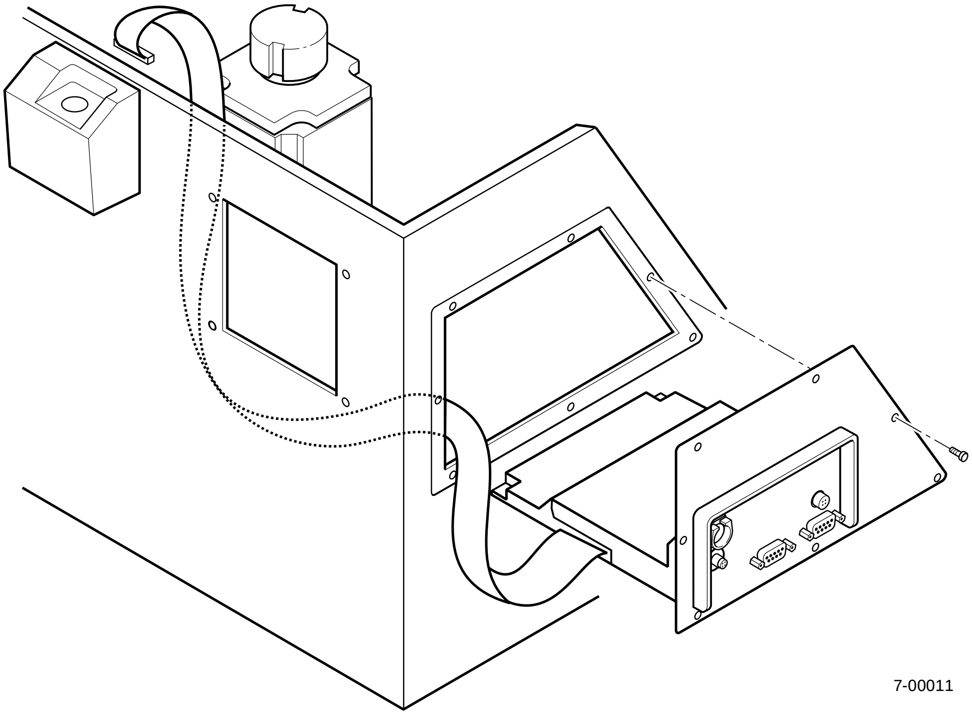


Figure 8-18. Removing Communications option assembly

8.6.3.1 Remote alarm harness and connector (Figure 8-19, 8-20)

Remove the remote alarm harness as follows. Install by reversing removal procedure.

1. Remove the Communications option assembly and disconnect the ribbon cable (Section 8.6.3).
2. Disconnect the remote alarm harness from the J2 connector on the PCB assembly.
3. Use a 19-mm open-end wrench to loosen the lock nut that holds the remote alarm connector to the option plate.
4. Push the harness and connector through the plate to remove.

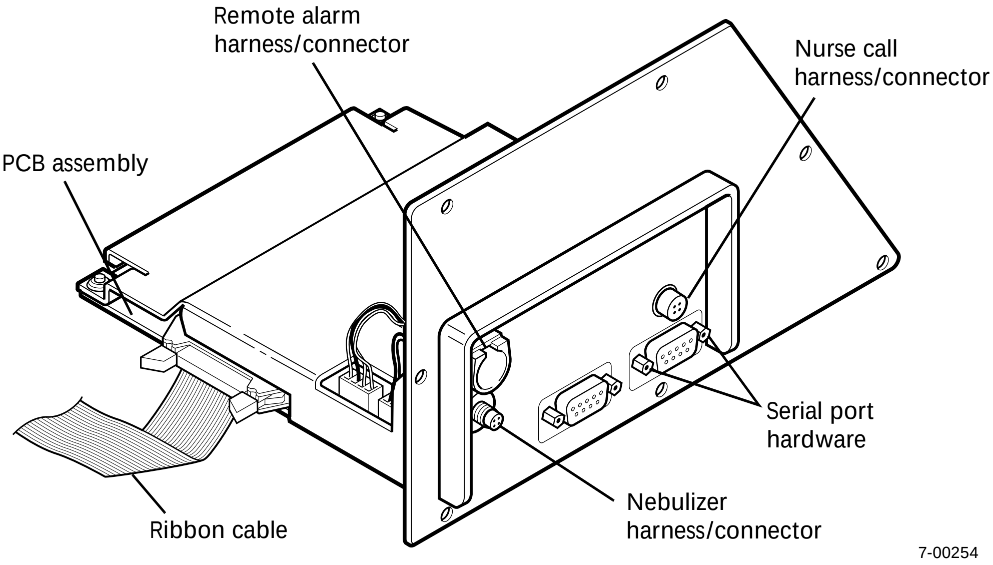

Remote alarm harness/connector
Nurse call harness/connector
PCB assembly
Serial port hardware
Ribbon cable
Nebulizer harness/connector
7-00254

Figure 8-19. Disassembling Communications option assembly (remote alarm, nebulizer, nurse call, and serial port hardware)

8.6.3.2 Nebulizer harness and connector (Figure 8-19, 8-20)

Remove the Communications option nebulizer harness as follows. Install by reversing removal procedure.

1. Remove the Communications option assembly and disconnect the ribbon cable (Section 8.6.3).
2. Remove the remote alarm harness and connector (Section 8.6.3.1).
3. Disconnect the nebulizer harness from the J3 connector on the PCB assembly.
4. Use a 14-mm open-end wrench to loosen the lock nut that holds the nebulizer connector to the option plate.
5. Push the harness and connector through the plate to remove.

8.6.3.3 Nurse call (central station) harness and connector (Figure 8-19, 8-20)

Remove the Communications option nurse call harness as follows. Install by following the instructions that come with the replacement nurse call harness.

1. Remove the Communications option assembly and disconnect the ribbon cable (Section 8.6.3).
2. Disconnect the nurse call harness from the J4 connector on the PCB assembly.
3. Use a cutting tool to cut the harness’ three-pin connector from the harness (so you can pull the harness through the clip inside the option panel).
4. Use a 10-mm open-end wrench to loosen the lock nut that holds the nurse call connector to the option plate.
5. Push the harness through the plate to remove.

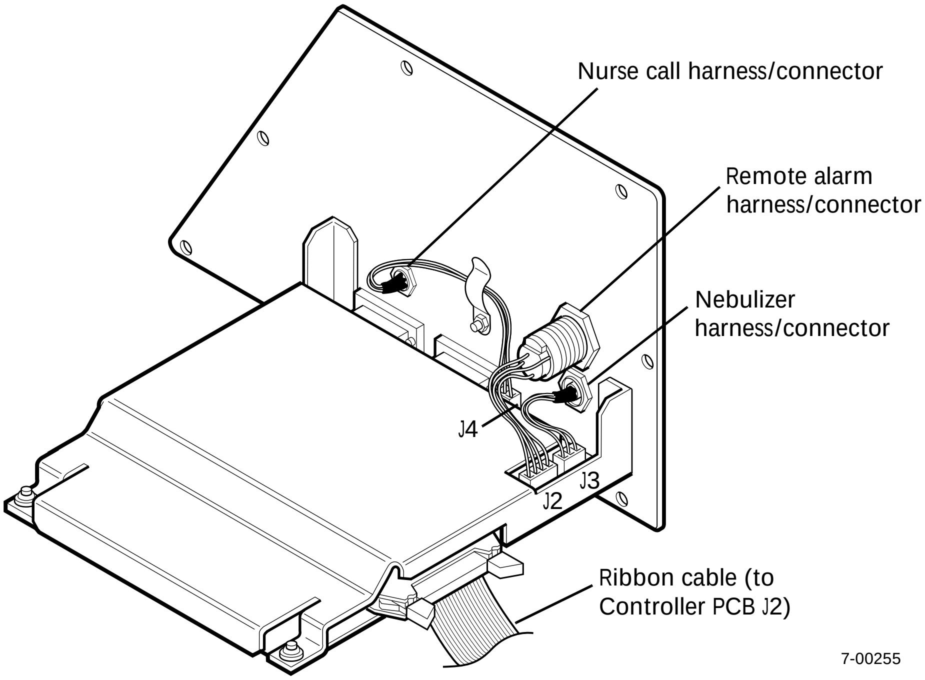

Nurse call harness/connector
Remote alarm harness/connector
Nebulizer harness/connector
J4
J3
J2
Ribbon cable (to Controller PCB J2)
7-00255

Figure 8-20. Removing harnesses/connectors from Communications option assembly

8.6.3.4 Serial (RS-232) port hardware (Figure 8-19)

Remove the Communications option serial port hardware as follows. Install by reversing removal procedure.

1. Remove the Communications option assembly and disconnect the ribbon cable (Section 8.6.3).
2. From the outside of the Communications option plate, use a 3/16-in. open-end wrench to remove the four female screws and flat washers from the two RS-232 ports.

8.6.3.5 Communications option PCB assembly (Figure 8-21)

Remove the Communications option PCB assembly as follows. Install by reversing removal procedure.

1. Remove the Communications option assembly and disconnect the ribbon cable (Section 8.6.3).
2. Remove the serial port hardware (Section 8.6.3.4).
3. Remove the remote alarm, nebulizer, and nurse call harnesses from their PCB connectors.
4. From the top of the PCB, remove the two M3 x 8 screws that hold the PCB to the option plate assembly (near the option plate).
5. From under the PCB, remove the two M3 x 8 screws that hold the PCB to the metal shell (part of the option plate assembly).
6. Remove the PCB assembly from the option plate assembly.

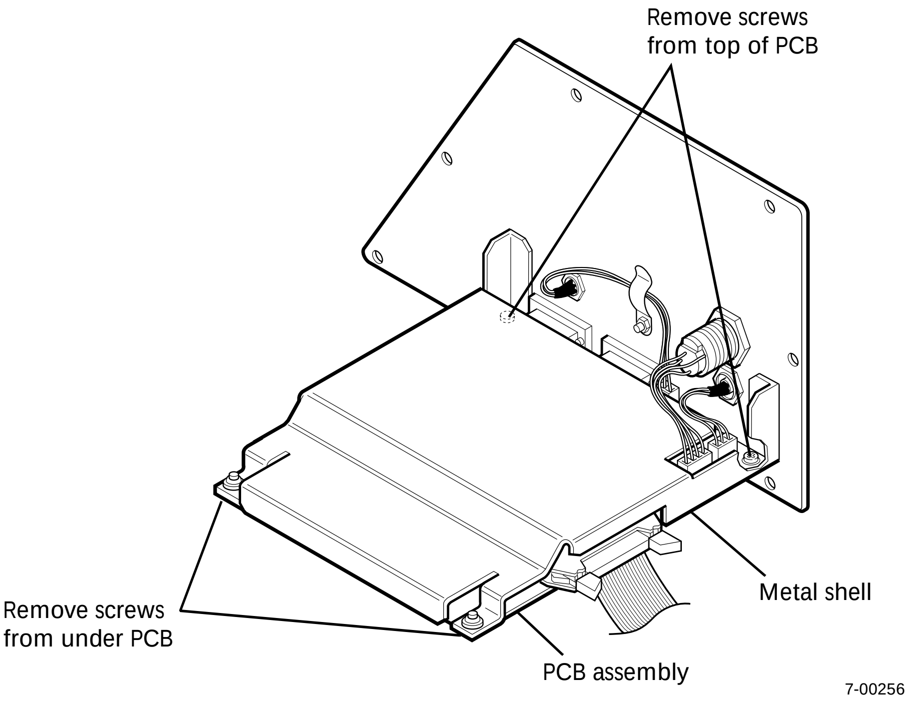


Figure 8-21. Removing the Communications option PCB assembly from the option plate assembly

8.6.3.6 Communications option plate assembly (Figure 8-21)

Remove the Communications option plate assembly as follows. With the exception of the nurse call harness and connector (which is installed according to instructions that come with the replacement harness), install by reversing removal procedure.

1. Remove the Communications option assembly from the ventilator and disconnect the ribbon cable (Section 8.6.3).
2. Remove the remote alarm harness (Section 8.6.3.1), nebulizer harness (Section 8.6.3.2), and nurse call harness (Section 8.6.3.3) from the option plate.
3. Remove the RS-232 port nuts (Section 8.6.3.4) from the option plate.
4. Remove the PCB assembly from the option plate assembly (Section 8.6.3.5).

8.6.3.7 Communications option ribbon cable (Figure 8-18)

Remove the Communications option ribbon cable as follows. Install by reversing removal procedure.

1. Remove the Communications option assembly and disconnect the ribbon cable from the Communications option assembly (Section 8.6.3).
2. Remove the main fan (Section 8.13.1).
3. Disconnect the ribbon cable from the J2 connector on the controller PCB.
4. Remove the Communications option ribbon cable from inside the cabinet (it is attached to the inside of the back of the cabinet with velcro strips).

8.6.4 Air intake cover and filter

Remove cover (Figure 8-22); then remove filter. Replace filter every 1000 hours or more often, as required. When installing filter, make sure tab on filter is toward your left, and make sure tab engages air flow sensor switch.

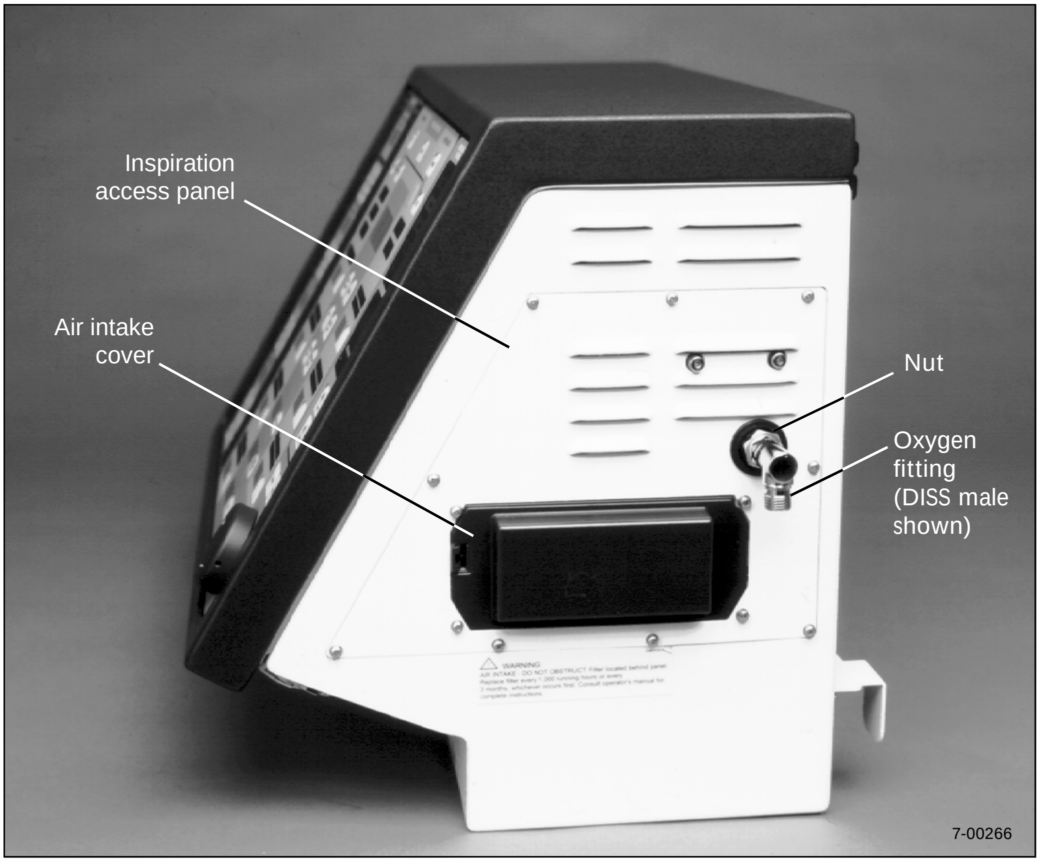

Inspiration access panel
Air intake cover
Nut
Oxygen fitting (DISS male shown)
7-00266

Figure 8-22. Inspiration access panel

8.6.5 Air flow thermistor assembly (Figure 8-23)

Remove air flow thermistor assembly as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect air flow thermistor assembly from ventilator head harness.
3. Using 2.5-mm hex key, remove two M3 x 8 screws and split-ring washers that attach air flow thermistor assembly to air intake manifold.

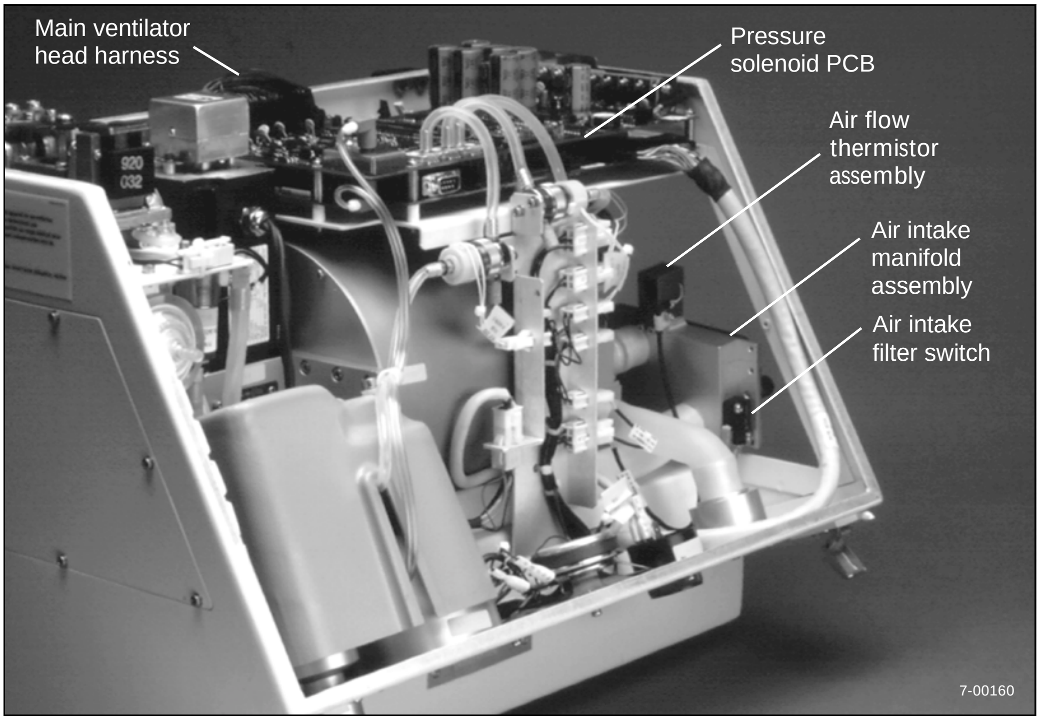

Main ventilator head harness
Pressure solenoid PCB
Air flow thermistor assembly
Air intake manifold assembly
Air intake filter switch
920 032
7-00160

Figure 8-23. Air flow thermistor assembly installed

8.6.6 Oxygen fitting, inspiration access panel, and air intake manifold assembly

Remove oxygen fitting, inspiration access panel, and air intake manifold assembly as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Remove oxygen adapter assembly (if ventilator is so equipped) from ventilator's male DISS fitting.
3. If required, remove male DISS fitting by unscrewing it while stabilizing nut with 19-mm wrench (Figure 8-22).

NOTE:

> You do not have to remove the ventilator's male DISS oxygen fitting in order to remove the inspiration access panel.

---

4. Using 2.5-mm hex key, remove two M3 x 8 screws and split-ring washers that attach air flow thermistor assembly to air intake manifold.
5. Disconnect wires from air intake filter switch (Figure 8-23).
6. Using 2.5-mm hex key, remove M3 x 8 screw, split-ring washer, and flat washer that attach tie wrap to just below top corner of air intake manifold. Free harness and cable tie from manifold.
7. From inside the inspiration access panel, use a 7-mm wrench to loosen the kep nut that holds the grounding strap to the inside of the panel. Remove the kep nut, M4 flat washer, and grounding strap from the panel.
8. Remove nine M3 x 8 POZIDRIV screws with captive washers from perimeter of inspiration access panel.
9. Remove two M4 shoulder bolts that are above louver close to oxygen fitting grommet.
10. Remove four M3 x 8 POZIDRIV screws with captive washers that attach air intake manifold assembly to panel.
11. Pull off inspiration access panel, leaving air intake manifold assembly behind (Figure 8-24). Maneuver panel around oxygen fitting, as required.

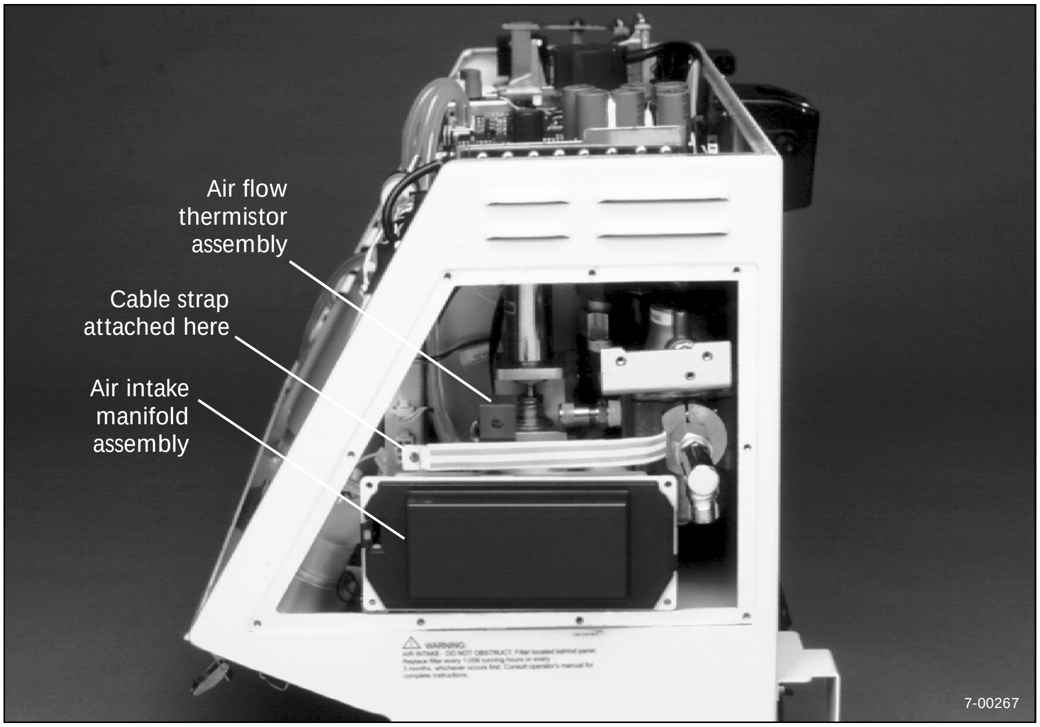

Air flow thermistor assembly
Cable strap attached here
Air intake manifold assembly
7-00267

Figure 8-24. Inspiration access panel removed

12. Pull manifold off three silicone tubes.
13. Disassemble manifold as required (Figure 8-25).

Caution

To prevent damage to the oxygen regulator assembly, maintain clean connections to the oxygen source. Never lubricate the threads of the oxygen fitting.

NOTE:

- When installing the male DISS fitting to the regulator body, first remove any PTFE tape (if reusing existing fitting) and apply new tape (P/N G-060759-00) to the threads. To prevent tape debris from coming loose and entering the pneumatic system, do not wrap tape around the first two threads.
- After installing or assembling male DISS fitting or any oxygen adapters, test for leaks. To leak test, apply leak test fluid (P/N 4-004489-00) with a suitable small brush to all connections between where the hose attaches to the adapters and where the male DISS fitting attaches to the regulator body. If new bubbles form, repair the leak. Use a clean cloth to remove the leak detector.

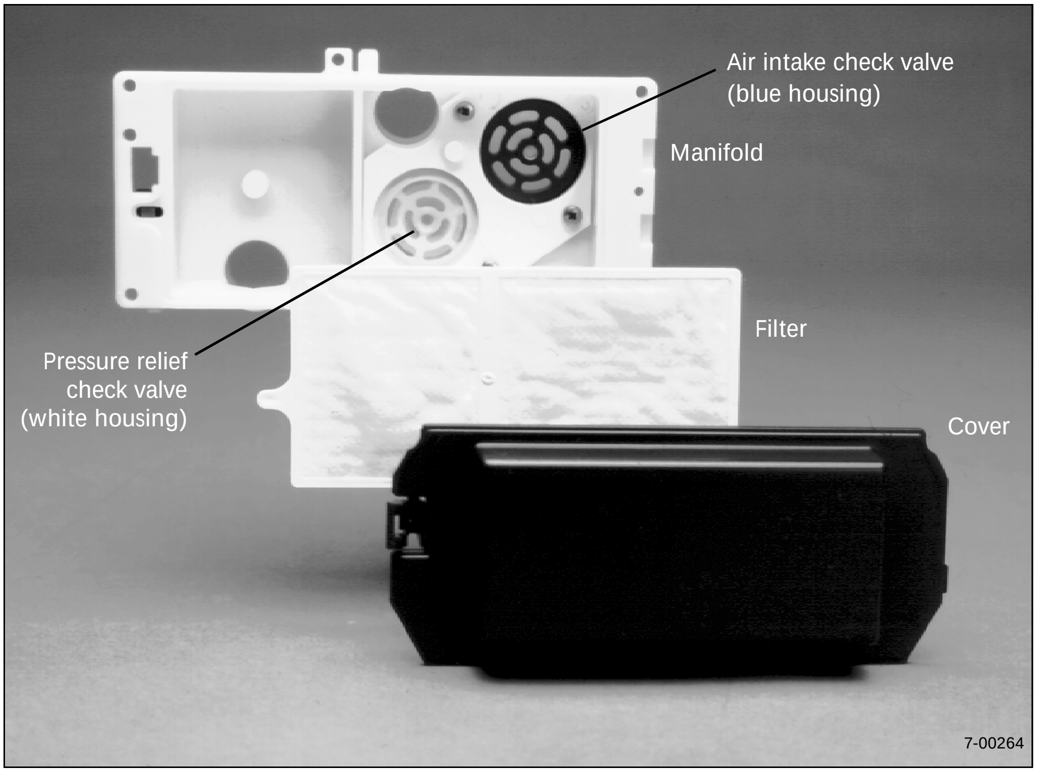

Air intake check valve (blue housing)
Manifold
Filter
Pressure relief check valve (white housing)
Cover
7-00264

Figure 8-25. Air intake manifold assembly disassembled

8.6.7 Air intake filter switch (Figure 8-23)

Remove air intake filter switch as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect air intake filter switch from ventilator head harness.

3. Remove two M3 x 14 POZIDRIV screws that attach switch to air intake manifold. Remove switch.

8.6.8 Flex arm mounting block (Figure 8-26)

Remove flex arm mounting block as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect main ventilator head harness from pressure solenoid PCB to provide access to mounting block retaining screws (Figure 8-23).
3. Using screwdriver with long (at least 20-cm) shaft, loosen bottom two M5 x 16 POZIDRIV screws and split-ring washers that retain block.
4. Remove top two M5 x 16 POZIDRIV screws and split-ring washers that retain block. Remove block by lifting up and off two bottom screws.

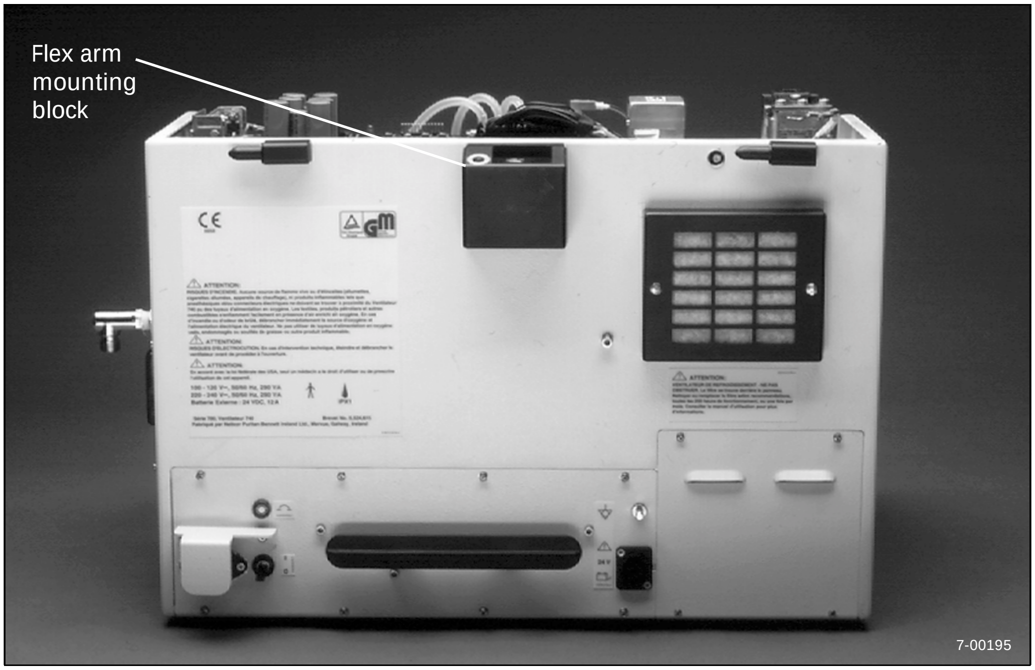


Figure 8-26. Flex arm mounting block

8.6.9 Removing/installing cabinet assembly

1. Remove all panels and components.
2. Transfer mini-support posts (that retain controller PCB) from existing to new cabinet assembly.
3. Transfer serial number plate (Figure 8-38) to new cabinet assembly:
   a. Using $^1/_8$-in. (3-mm) drill bit, drill out rivets that secure plate.
   b. Reinstall serial number plate to new cabinet. Mount with pop rivets (P/N G-061182-00) in holes provided.
4. Install a label kit (see Section 9 for part numbers) on new cabinet assembly.

Warning

The failure to install warning, caution, and identification labels may result in personal injury, equipment, or property damage.

5. Reassemble ventilator by reinstalling panels and components.

NOTE:

When installing a new cabinet assembly, always remove and reattach the serial number plate. It is important that the serial number plate remain with the unit, as ventilator serial numbers are matched with subassembly serial numbers.

8.7 Oxygen regulator, oxygen solenoid, mixing manifold, and cylinder inlet check valve

Warning

To prevent possible injury, do not remove the dust cap from the oxygen regulator extension adapter (brass part protruding from the side of the regulator) when the regulator is pressurized. If the extension adapter is not tightened, the valve may fly off when the dust cap is removed.

Caution

To prevent damage to the oxygen regulator, maintain clean connections to the oxygen source. Never lubricate the threads of the oxygen fitting.

NOTE:

- Replace the oxygen regulator every 15,000 hours. It is part of the 15,000- and 30,000-hour preventive maintenance kits.
- If the monitored oxygen concentration of delivered gas is too low, the outlet or inlet check valve may be stuck open. Apply negative pressure to the wye. If system pressure stays low, check for a stuck check valve.

8.7.1 Removing oxygen regulator, oxygen solenoid, mixing manifold, and cylinder inlet check valve (Figure 8-27)

Remove the oxygen regulator, oxygen solenoid assembly, mixing manifold, and cylinder inlet check valve as follows.

1. Remove inspiration access panel and air intake manifold assembly (Section 8.6.6).

Caution

To prevent equipment damage, never disconnect any solenoids while power is applied.

2. Disconnect oxygen solenoid connector from ventilator head harness at cable management bar.
3. Disconnect oxygen regulator pressure transducer harness from pressure solenoid PCB. Free harness from clip on cabinet.
4. Pull out oxygen regulator and oxygen solenoid assembly.

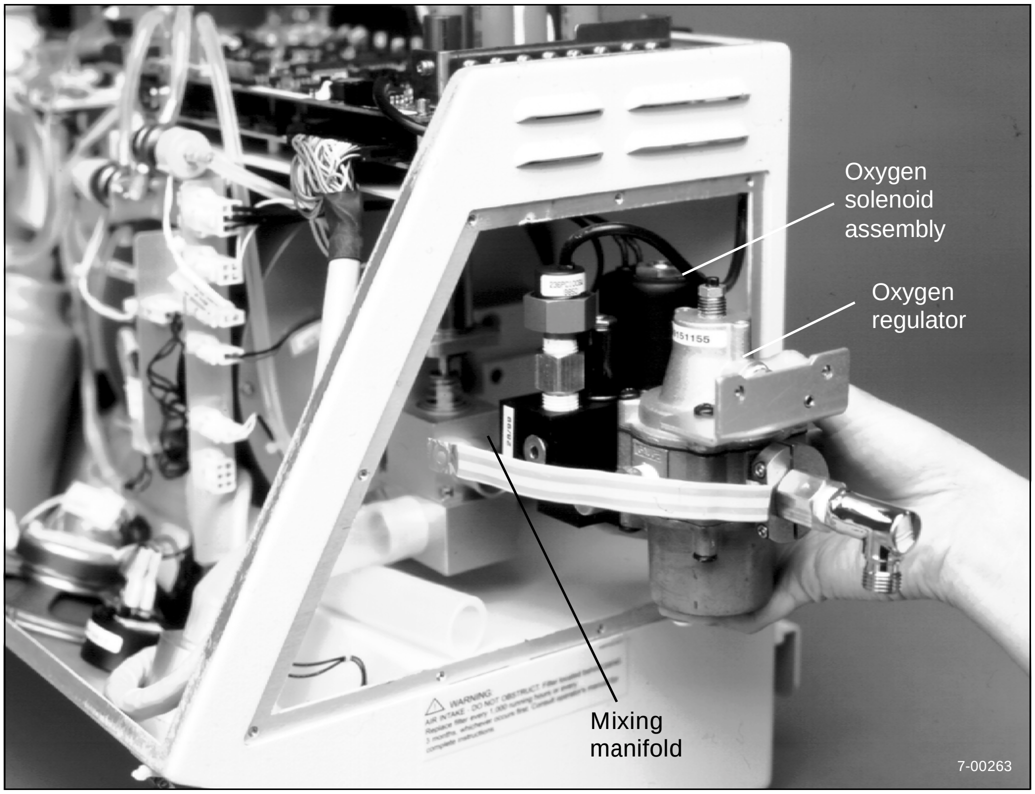


Figure 8-27. Removing oxygen regulator/oxygen solenoid assembly

5. To remove the grounding strap from the regulator, use a 3-mm hex key to loosen the two M3 x 25 screws on the grounding strap, then remove the grounding strap from the regulator.
6. To separate the oxygen solenoid assembly from the oxygen regulator, use a 2.5-mm allen key to remove the four hex screws (Figure 8-28).

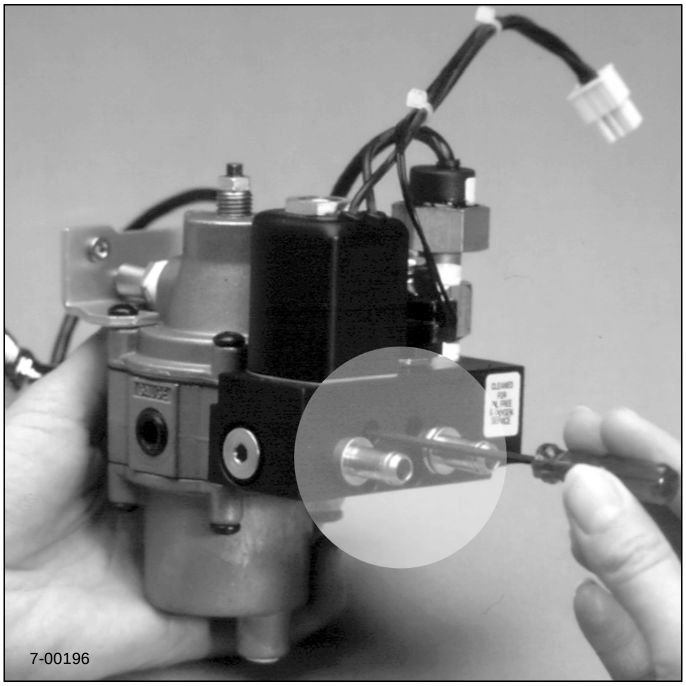


Figure 8-28. Separating the oxygen solenoid assembly from the oxygen regulator

7. Remove mixing manifold, as follows:
   a. Using 2.5-mm hex driver, loosen four M3 x 10 screws and split-ring washers.
   b. Pull out manifold. Inlet check valve and gasket will also come out (Figure 8-29).

Caution

Be extremely careful to prevent debris of any kind from entering the cylinder while the check valve is off. Debris can permanently damage the piston/cylinder assembly.

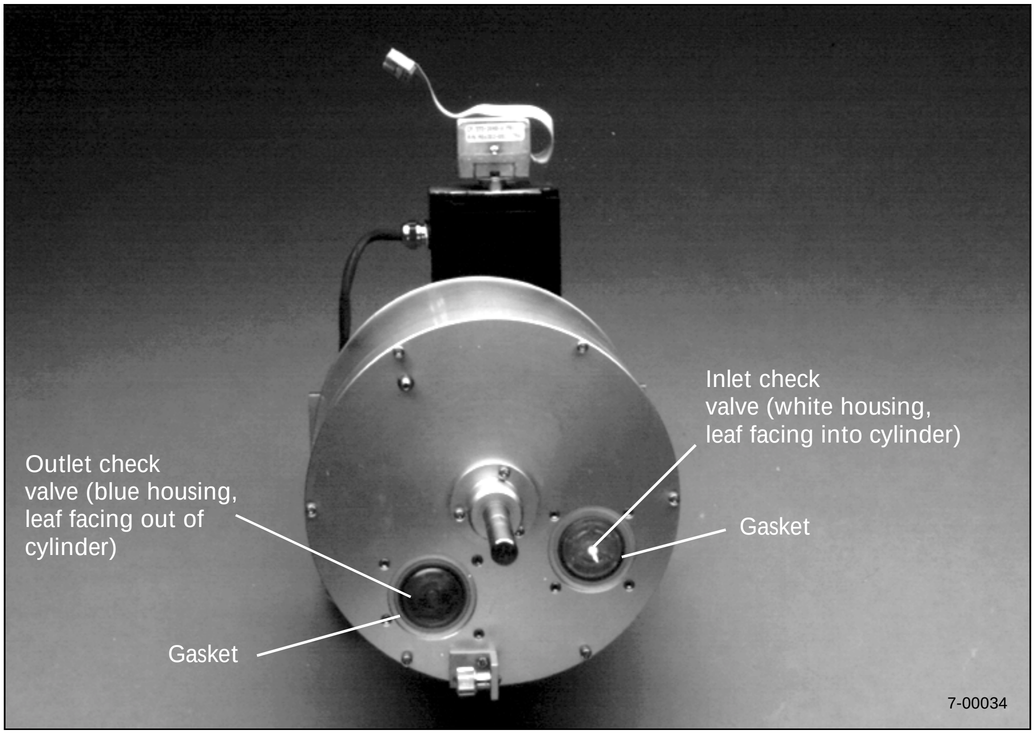

Inlet check
valve (white housing,
leaf facing into cylinder)
Outlet check
valve (blue housing,
leaf facing out of
cylinder)
Gasket
Gasket
7-00034

Figure 8-29. Cylinder check valves

8.7.2 Installing oxygen regulator, oxygen solenoid assembly, mixing manifold, and cylinder inlet check valve

Install the oxygen regulator, oxygen solenoid assembly, mixing manifold, and cylinder inlet check valve by reversing removal procedure.

Warning

To minimize fire hazard, inspect and clean as necessary any ventilator parts that come into contact with oxygen.

NOTE:

- When reinstalling the inlet check valve, make sure leaf faces toward the inside of the ventilator. Installing the check valve backwards prevents the unit from ventilating.
- To prevent the check valve and gasket from falling out during installation, try inclining the ventilator slightly.
- When installing a new oxygen solenoid assembly, always (1) input the calibration constants for the new assembly into NVRAM (Section 4), and (2) install calibration constants label supplied over existing “OXYGEN MIXING SYSTEM” section of Calibration Constants label on underside of ventilator lid.
- When installing a new oxygen solenoid assembly, transfer the existing oxygen pressure transducer (with 19-mm extension adapter) to the new oxygen solenoid assembly. Replace PTFE tape (P/N G-060759-00) on the threads of the pressure transducer and extension adapter.
- When installing a new oxygen regulator, replace all four hex screws and ensure that they are tightened.

8.7.3 Oxygen regulator pressure transducer (Figure 8-30)

Remove the oxygen regulator pressure transducer as follows. Install by reversing removal procedure.

1. Remove oxygen regulator (Section 8.7, steps 1 through 4).
2. Using 19-mm open-ended wrench, remove pressure sensor from oxygen regulator port.

NOTE:

- When installing the sensor, remove any existing tape, and apply new PTFE tape (G-060759-00) on the threads. To prevent tape debris from coming loose and entering the pneumatic system, do not wrap tape around the first two threads.
- After installing the transducer, run an oxygen regulator pressure transducer calibration (Section 4.2.3.2.2).

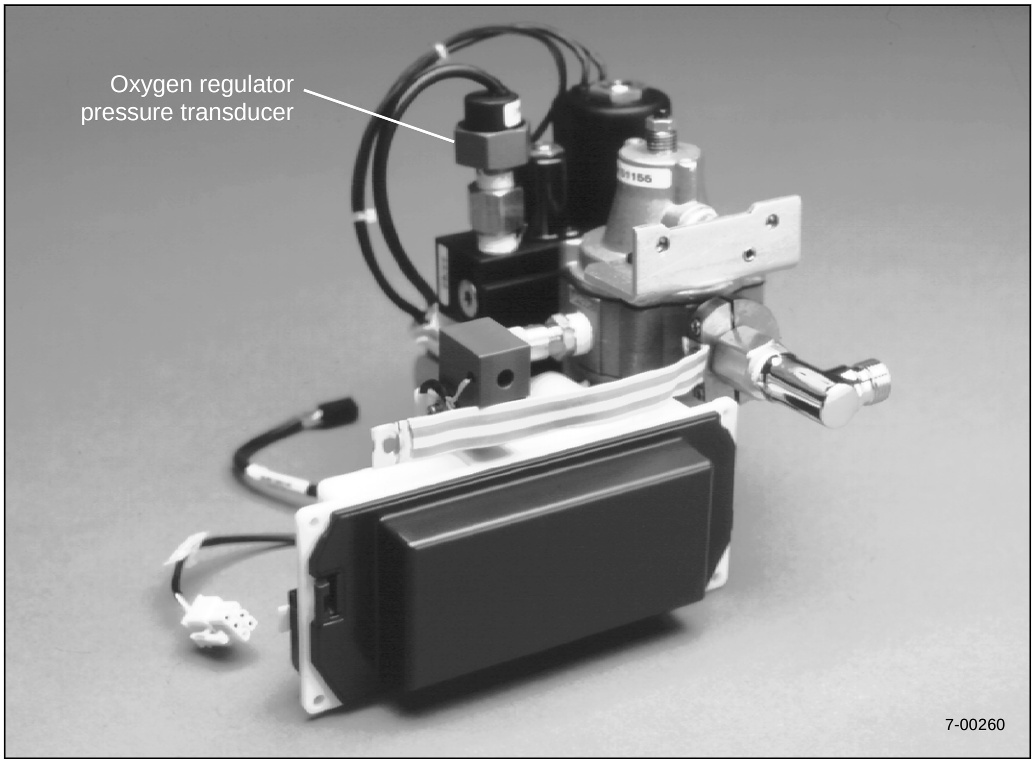


Figure 8-30. Oxygen regulator pressure transducer

8.8 Inspiration manifold assembly

Warning

The safety valve solenoid can get very hot. To prevent injury, be careful when servicing the solenoid or other inspiration manifold components.

8.8.1 Oxygen sensor

Remove the oxygen sensor as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect sensor:
    - For oxygen sensors with an integral harness: disconnect the sensor harness from the ventilator head harness.
    - For oxygen sensors with a removable sensor harness: disconnect the sensor harness from the top of the sensor.
3. Remove the sensor: pull out sensors with an integral harness, and unscrew sensors with a removable harness (Figure 8-31).
4. Install the new sensor (Figure 8-32):
    - If you are replacing an oxygen sensor with integral harness, order an oxygen sensor kit (P/N G-062009-00), which includes the sensor, sensor harness, adapter, and screws and washers.
    - If you are replacing an oxygen sensor with removable harness, order the oxygen sensor FRU (P/N G-062010-00), which includes the oxygen sensor only.

NOTE:

- When installing the oxygen sensor, make sure it is fully seated.
- After installing the oxygen sensor, always perform an oxygen sensor calibration (Section 4.2.3.2.2).

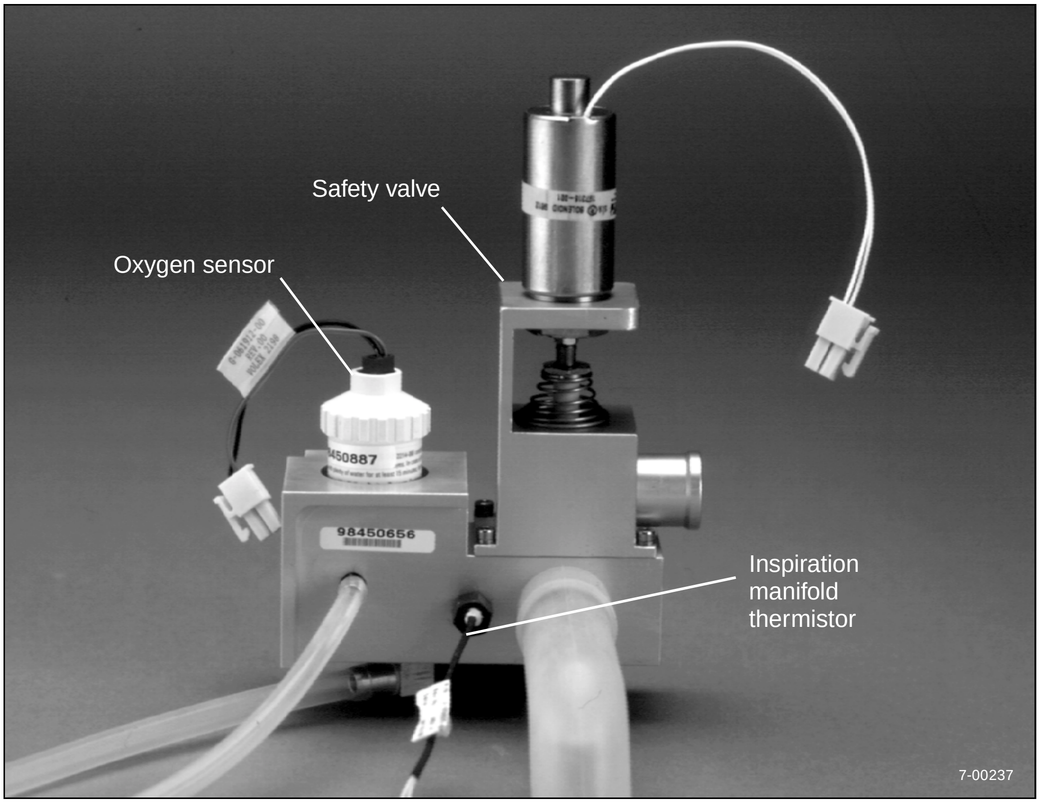

Safety valve
Oxygen sensor
Inspiration manifold thermistor
98450656
450887
7-00237

Figure 8-31. Inspiration manifold assembly

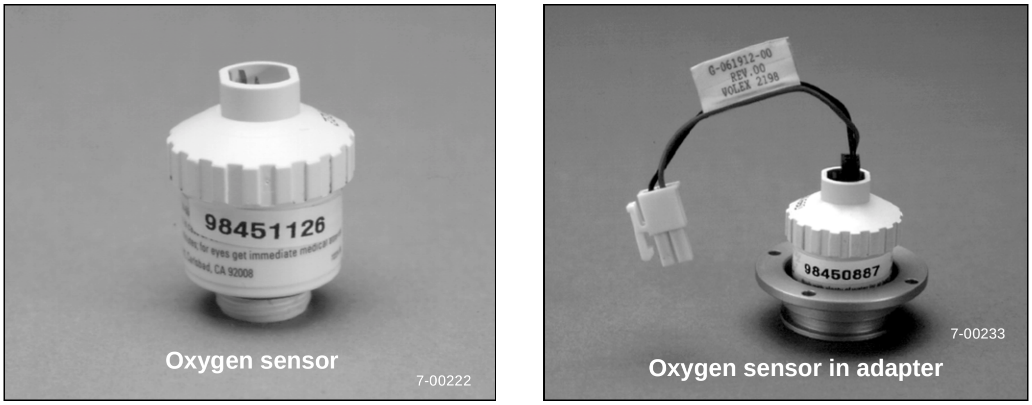

98451126
Oxygen sensor
7-00222
G-061912-00 REV.00 VOLEX 2198
98450887
7-00233
Oxygen sensor in adapter

Figure 8-32. Oxygen sensor with and without adapter

8.8.2 Inspiration manifold thermistor (Figure 8-31)

Remove the inspiration manifold thermistor as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect thermistor from ventilator head harness.
3. Using 10-mm (for previous version) or 19-mm (for current version) open-ended wrench, remove thermistor.

8.8.3 Safety valve assembly (Figure 8-31)

Warning

The safety valve solenoid can get very hot. To prevent burns, be careful when servicing the safety valve or adjacent inspiration manifold components.

Remove the safety valve assembly as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Remove inspiration access panel (Section 8.6.6, steps 3 through 11).

Caution

To prevent equipment damage, never disconnect any solenoids while power is applied.

3. Disconnect safety valve solenoid from ventilator head harness.
4. Using 2.5-mm hex driver, remove four M3 x 8 screws and split-ring washers that attach safety valve assembly to inspiration manifold.

8.8.4 Removing/installing inspiration manifold assembly (Figure 8-33)

Remove the inspiration manifold assembly as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Remove inspiration access panel and air intake manifold assembly (Section 8.6.6).

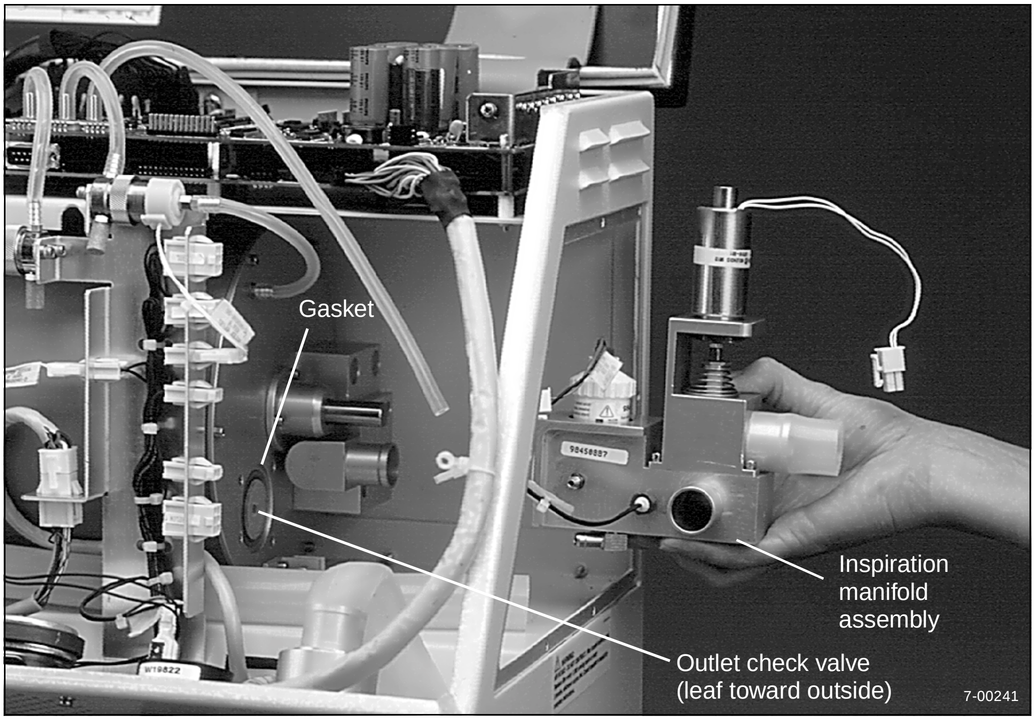
Caution

To prevent equipment damage, never disconnect any solenoids while power is applied.

3. Disconnect safety valve solenoid, oxygen sensor, and thermistor from ventilator head harness at cable management bar.
4. Disconnect two pressure-sensing tubes from manifold (inspiration/atmospheric pressure sensing and exhalation valve control). Disconnect large-bore elbow tube.
5. Using 2.5-mm hex driver and/or key, remove four M3 x 8 screws and split-ring washers that attach manifold assembly to cylinder. Remove manifold assembly.
6. To remove check valve, remove gasket, then check valve.

NOTE:

- If the monitored oxygen concentration of delivered gas is too low, the outlet or inlet check valve may be stuck open. Apply negative pressure to the wye. If system pressure stays low, check for a stuck check valve.
- When installing the outlet check valve, make sure the leaf faces toward outside of ventilator. Installing the check valve backwards prevents the unit from ventilating.
- To prevent the check valve and gasket from falling out during installation, try inclining the ventilator slightly.



Gasket
Inspiration manifold assembly
Outlet check valve (leaf toward outside)
7-00241

Figure 8-33. Removing inspiration manifold assembly

8.9 Exhalation assembly

8.9.1 Exhalation assembly cover (Figure 8-34)

Remove the exhalation assembly cover as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Remove options panel plate (Section 8.6.2).
3. Remove filter from reservoir assembly.
4. Disconnect pilot tube from side of exhalation valve.
5. Using 4-mm hex driver, remove M5 x 12 screw and flat washer that retain cover and retaining clip. Remove clip. Lift off cover.

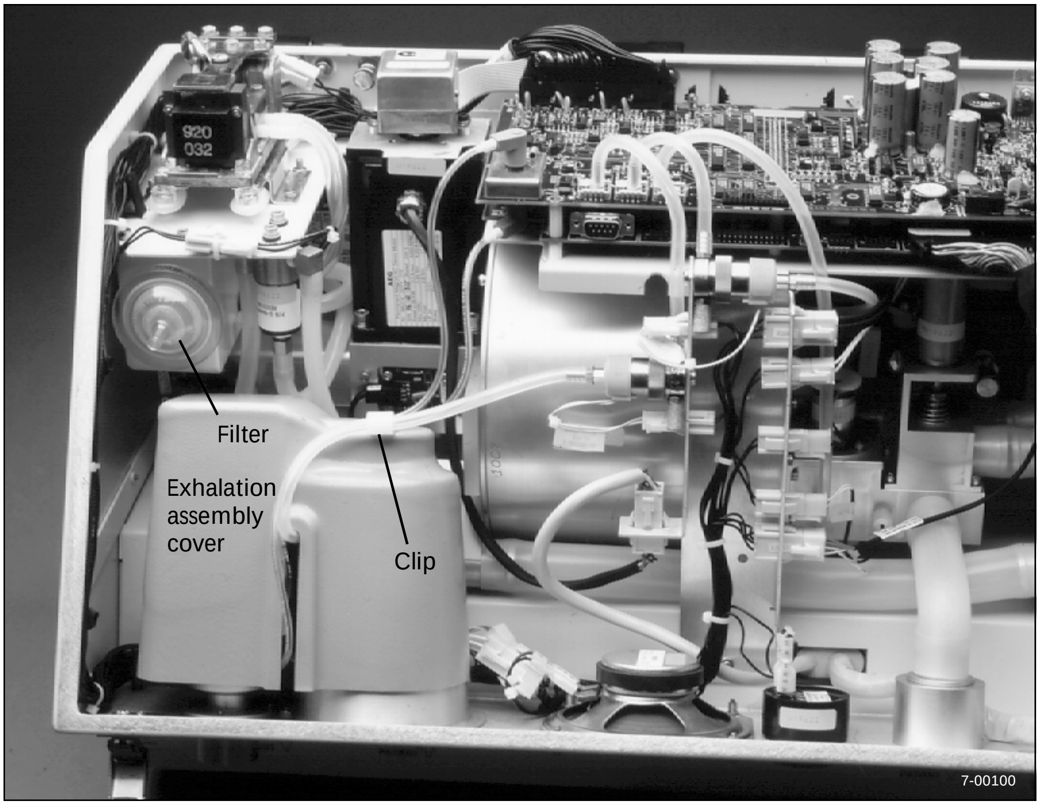


Figure 8-34. Exhalation assembly cover

8.9.2 Exhalation heater and thermistor assemblies

8.9.2.1 Removing exhalation heater and thermistor assemblies (Figure 8-35 and Figure 8-36)

Remove the exhalation heater or thermistor assembly as follows.

1. Remove exhalation assembly cover (Section 8.9.1).
2. Disconnect heater or thermistor assembly harness from ventilator head harness.
3. Remove clip surrounding top of flow sensor assembly.
4. Remove thermistor (if applicable) by pulling thermistor bead from clip. The heater does not require removal to do so.
5. Remove heater (if applicable).
6. Finish removing thermistor assembly (if applicable):
    a. Using 2.5-mm hex driver, remove screw and detach metal tab (which houses other thermistor) at top of flow sensor assembly.
    b. Remove thermistor.
7. Finish removing heater assembly (if applicable) by removing other heater-retaining clip; then remove heater.

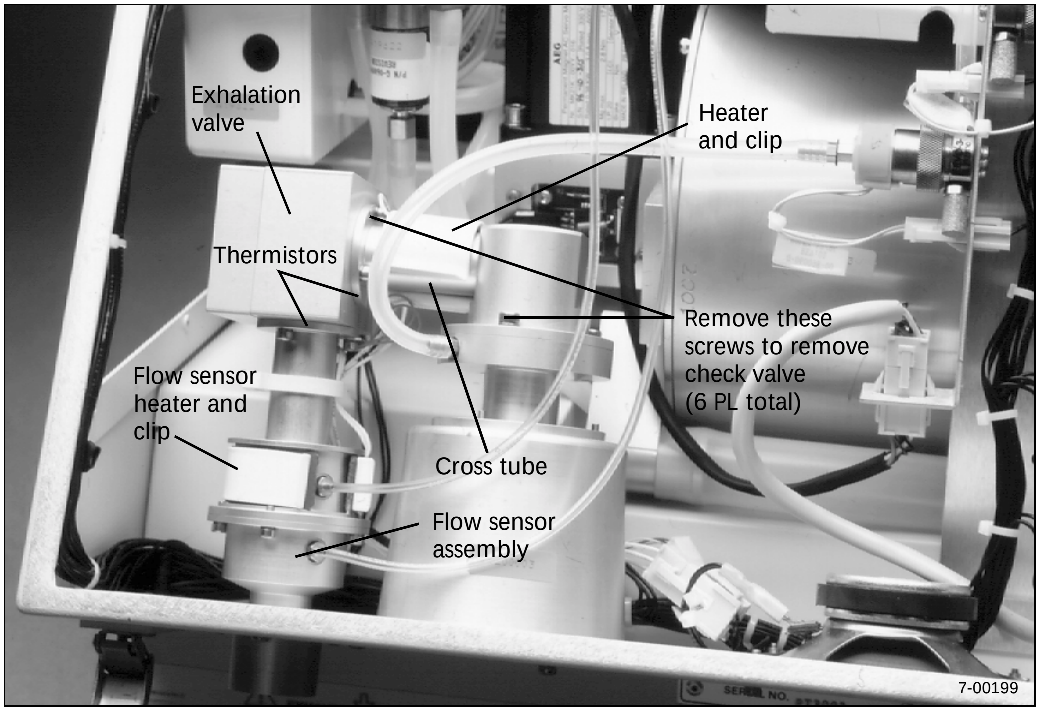

Exhalation valve
Heater and clip
Thermistors
Remove these screws to remove check valve (6 PL total)
Flow sensor heater and clip
Cross tube
Flow sensor assembly
7-00199

Figure 8-35. Exhalation assembly installed

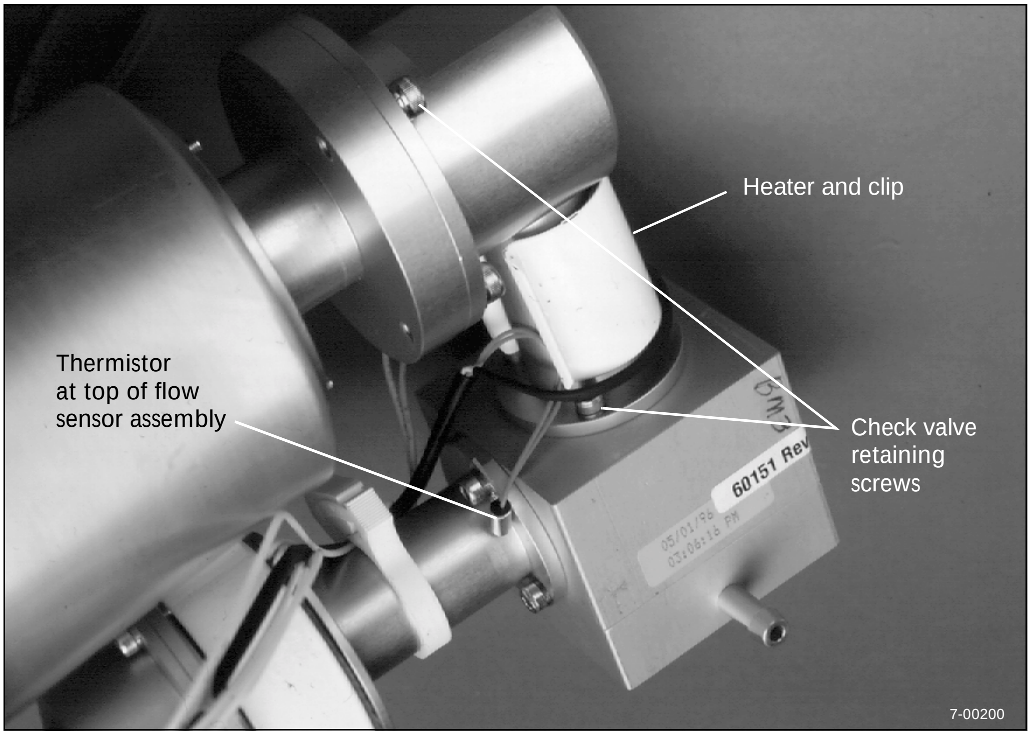

Heater and clip
Thermistor at top of flow sensor assembly
Check valve retaining screws
60151 Rev
7-00200

Figure 8-36. Exhalation heater and thermistor assemblies

8.9.2.2 Installing exhalation heater and thermistor assemblies (Figure 8-35 and Figure 8-36)

1. Install heater assembly by reversing removal procedure, wrapping long heater around top of flow sensor housing and short heater around cross tube.
2. Install thermistor assembly:
   a. Install black thermistor bead by threading bead and approximately 15 mm of thermistor wire through hole in clip from outside (Figure 8-37). Then, install clip on flow sensor housing.
   b. When installing thermistor housed within metal tab, attach tab to inner flow sensor screw (near flat edge of flow sensor assembly). Angle thermistor tab to obtain maximum contact with exhalation valve metal housing.

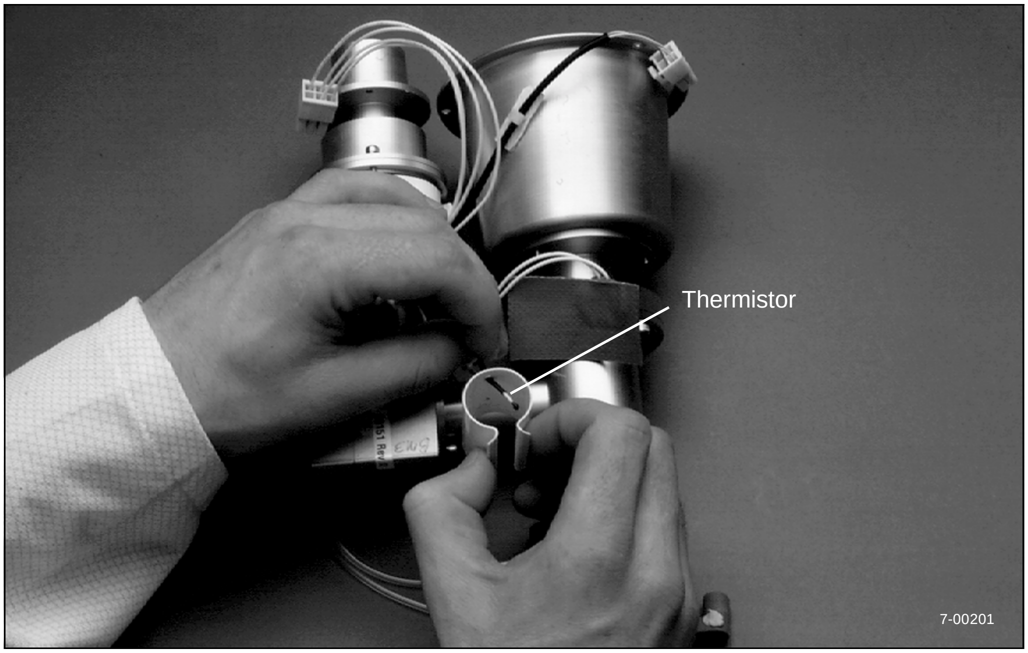


Figure 8-37. Threading thermistor through flow sensor heater clip

8.9.3 Exhalation assembly (Figure 8-35)

Remove the exhalation assembly as follows. Install by reversing removal procedure.

1. Remove exhalation assembly cover (Section 8.9.1).
2. Remove expiratory filter.
3. Disconnect heater and thermistor harnesses from ventilator head harness.
4. Remove all tubes from exhalation assembly (two tubes from both sides of flow sensor, one tube from check valve, and one tube from exhalation valve).
5. Remove four M3 x 8 POZIDRIV screws with captive washers from around gas exhaust (Figure 8-38). Remove three M3 x 8 POZIDRIV screws with captive washers, and nuts with captive lockwashers from expiratory filter housing. Remove exhalation assembly.

NOTE:

When reinstalling exhalation assembly, take care to install all tubes in correct positions.

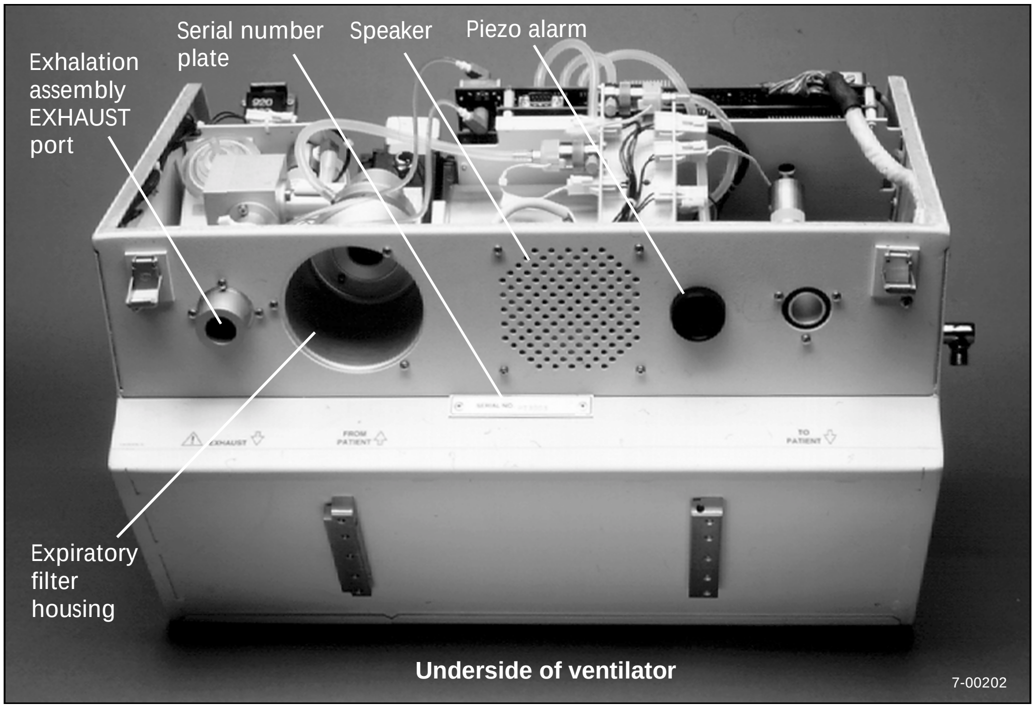

Exhalation assembly EXHAUST port
Serial number plate
Speaker
Piezo alarm
Expiratory filter housing
Underside of ventilator
7-00202

Figure 8-38. Exhalation assembly, speaker, and piezo alarm mounting

8.9.4 Exhalation check valve (Figure 8-35)

Remove the exhalation check valve, as follows. Install by reversing removal procedure.

1. Remove exhalation assembly (Section 8.9.3).
2. Remove heater and thermistor assemblies and spring clip from cross tube to allow access to screws.
3. Using 2.5-mm hex key, remove three M3 x 8 screws and split-ring washers from cross tube (Figure 8-36).
4. Using 3-mm hex key, remove three M4 x 12 screws and split-ring washers from check valve housing. Remove gasket, then check valve (Figure 8-39).

NOTE:

- When installing the check valve, make sure the brass knob faces upward (into ventilator). Installing the check valve backwards prevents the unit from ventilating properly.
- When reassembling the check valve housing, orient it so the exhalation pressure port faces at an angle towards the two flow sensor ports.

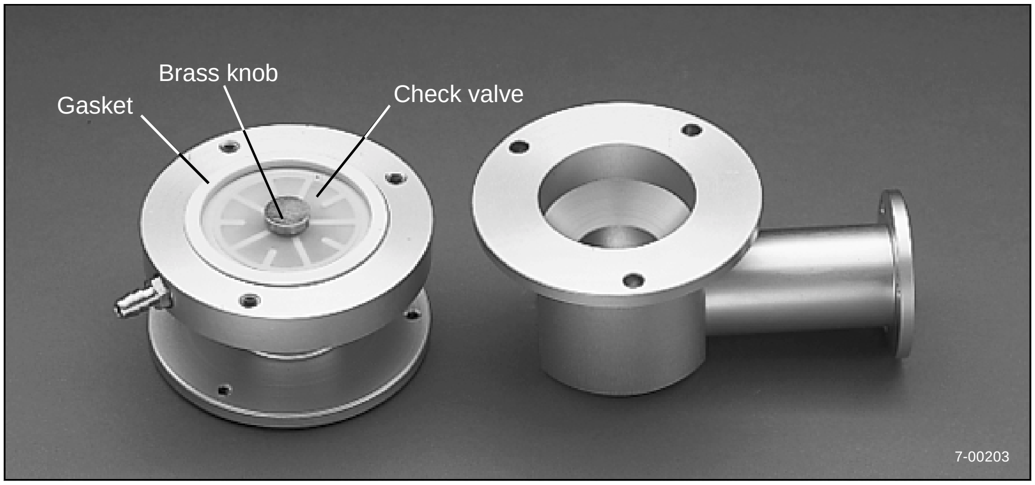


Figure 8-39. Exhalation check valve in position

8.9.5 Exhalation valve (Figure 8-35)

Remove the exhalation valve as follows. Install by reversing removal procedure.

1. Remove exhalation assembly (Section 8.9.3).
2. Remove heater and thermistor assemblies and spring clip from cross tube.
3. Using 2.5-mm hex key and/or driver, remove three M3 x 8 POZIDRIV screws and split-ring washers that attach exhalation valve to cross tube block, and three M3 x 8 POZIDRIV screws and split-ring washers that attach valve to flow sensor. Remove valve.

8.9.6 Exhalation flow sensor assembly (Figure 8-35)

Remove the exhalation flow sensor assembly as follows. Install by reversing removal procedure.

1. Remove exhalation assembly (Section 8.9.2).
2. Using 3-mm hex driver, remove three M3 x 8 screws and split-ring washers that attach flow sensor assembly to exhalation valve. Remove flow sensor assembly.
3. Remove clip and heater from flow sensor assembly.
4. Remove and save flow sensor tube assembly for reinstallation.

NOTE:

- Install the thermistor bead with the flow sensor assembly attaching screw, as shown in Figure 8-36. Install the flow sensor assembly so the flat edge is as shown in Figure 8-36.
- When installing a new flow sensor assembly, always (1) input the calibration constant for the new assembly into NVRAM (Section 4), and (2) install calibration constants label supplied over existing "FLOW SENSOR" section of Calibration Constants label on underside of ventilator lid.

8.10 Cable management bar, PCBs, speaker, and piezo alarm (Figure 8-40)

8.10.1 Speaker (Figure 8-40)

Remove the speaker as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect ventilator head harness from speaker terminals.
3. Remove four M3 x 12 POZIDRIV screws with captive washers from beneath speaker (Figure 8-38). Lift out speaker.

NOTE:

When installing the speaker, orient the terminals to the left. The polarity of the speaker wires is unimportant.

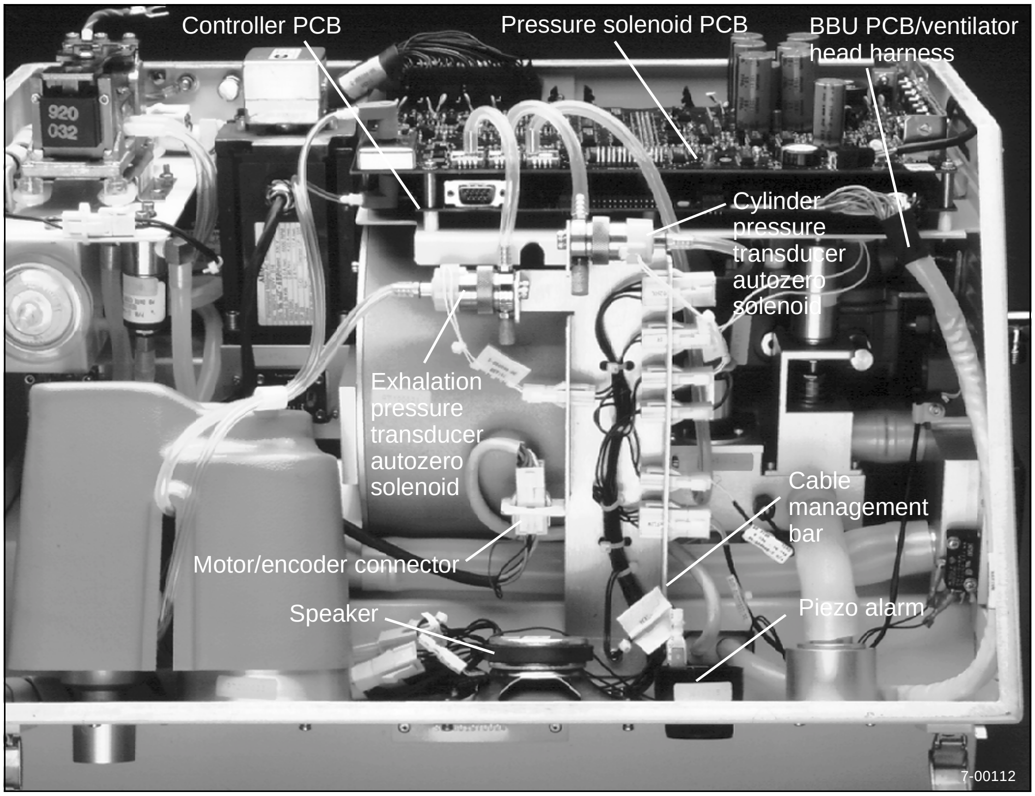

Controller PCB
Pressure solenoid PCB
BBU PCB/ventilator head harness
Cylinder pressure transducer autozero solenoid
Exhalation pressure transducer autozero solenoid
Cable management bar
Motor/encoder connector
Speaker
Piezo alarm
7-00112

Figure 8-40. Cable management bar, PCBs, speaker, and piezo alarm

8.10.2 Piezo alarm (Figure 8-40)

Remove the piezo alarm as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect ventilator head harness from alarm.
3. Unscrew alarm cap (Figure 8-38). Remove alarm and rubber washer.

NOTE:

When installing the piezo alarm, connect the ventilator head harness wires to the + and - terminals that are next to each other. The alarm will not emit the desired tone if the wires are connected improperly.

8.10.3 Pressure solenoid PCB and controller PCB (Figure 8-40)

Caution

To prevent damage to ESD-sensitive components, always follow ESD guidelines when handling the pressure solenoid and controller PCBs.

- To prevent stress to pressure solenoid PCB, handle PCB by cutout (Figure 8-41) when removing and installing.
- To avoid damaging the transducers, remove tubes from the transducer ports very carefully.

8.10.3.1 Removing/installing pressure solenoid PCB

Remove the pressure solenoid PCB as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect all tubes and harnesses from pressure solenoid PCB. To avoid damaging the transducers, take special care when removing the tubes from the transducer ports.
3. Using 5-mm nutdriver, remove seven nuts and internal lockwashers hex standoffs and split-ring washers that retain pressure solenoid PCB. Lift off pressure solenoid PCB using cutout at back of PCB.

NOTE:

When installing a pressure solenoid PCB, do the following:

- Make sure to connect the pressure transducer sensing tubes to the correct ports, as shown in Figure 8-41.
- Perform an oxygen regulator pressure transducer calibration (Section 4.2.3.2.2).
- Perform an FIO_2 calibration check (Section 4.2.3.2.2).
- IMPORTANT: *For ventilators with software revision H or later*, always input the calibration constants of the new pressure solenoid PCB into NVRAM using the *Update prsol nvram* function in the service menu (Section 4.2.3.5).
- IMPORTANT: If you perform the *Update prsol nvram* function, you must then perform the *O2 pressure calib* and *FIO2 sensor calib* functions. To ensure correct function of the pressure solenoid PCB, you must perform the *Update prsol nvram* function **before** the *O2 pressure calib* and *FIO2 sensor calib* functions.

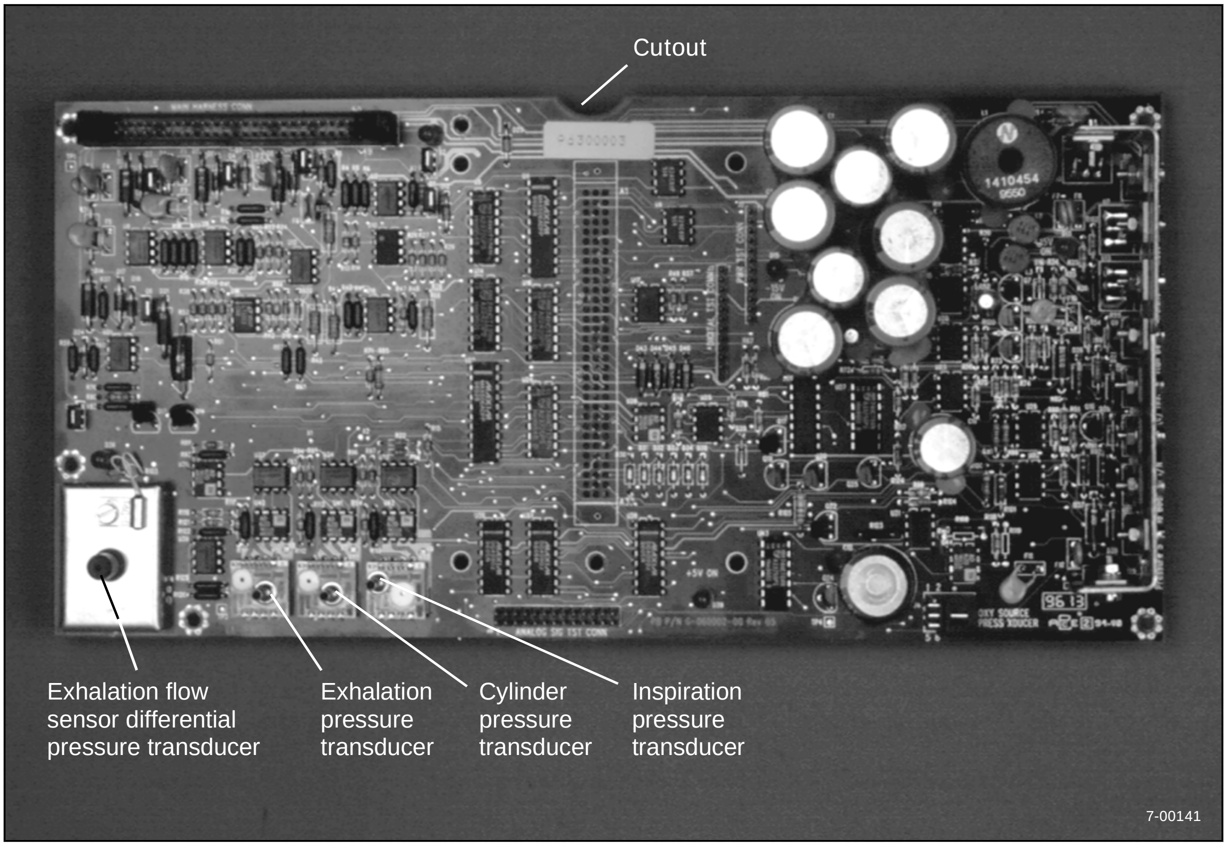

Cutout
Exhalation flow sensor differential pressure transducer
Exhalation pressure transducer
Cylinder pressure transducer
Inspiration pressure transducer
7-00141

Figure 8-41. Pressure solenoid PCB tube connectors

8.10.3.2 Removing/installing controller PCB

Remove the controller PCB as follows. Install by reversing removal procedure.

1. Remove the pressure solenoid PCB (Section 8.10.3.1).
2. Disconnect harnesses.
3. Unscrew seven standoffs, and lift off PCB.
4. If you are installing a new controller PCB, transfer software EPROMs (erasable programmable read-only memory) (U69, U70, U79, and U80) from existing PCB to new PCB (Section 8.10.3.3). If NVRAM (nonvolatile RAM) remains functional, transfer NVRAM (U6) from existing controller PCB to new PCB. If NVRAM has failed, install new NVRAM into controller PCB, then update NVRAM with ventilator data (Section 8.10.3.5).

NOTE:

- When installing a new controller PCB, always transfer the NVRAM and software EPROMs from the existing controller PCB to the new PCB. The NVRAM contains calibration constants specific to the components in your ventilator. The EPROMs contain the ventilator software. The unit cannot ventilate if either the NVRAM or EPROMs are missing.
- When replacing a NVRAM, be sure that the ventilator is running software revision J or later, and upgrade the software if necessary. Use the **Reset serial number** function (Section 4.2.3.7) to enter the ventilator’s serial number once the new NVRAM is installed.
- If the NVRAM on the existing controller PCB fails, you must install a new NVRAM into the controller PCB and update the new NVRAM with ventilator data following the procedure in Section 8.10.3.5.

8.10.3.3 Removing/installing software EPROMs (Figure 8-42)

Remove the software EPROMs (erasable programmable read-only memory) from the controller PCB as follows. Install by reversing removal procedure.

Caution

To prevent ESD damage, always follow ESD guidelines when handling PCBs or EPROMs.

1. Open and prop lid (Section 8.5.1).
2. Disconnect ventilator head harness from upper lefthand corner of pressure solenoid PCB.
3. Using 5-mm nutdriver, remove seven nuts and internal lockwashers that retain pressure solenoid PCB. Lift PCB forward so it rests on speaker.
4. Remove set of four software EPROMs (U69, U70, U79, and U80) using 32-pin, PLCC-type EPROM removal tool (P/N G-061914-00) (Figure 8-43).

NOTE:

When installing EPROMs:

- Make sure they are oriented so that notch is in the upper lefthand corner.
- Align each EPROM on its socket, then apply pressure evenly to completely insert the EPROM.

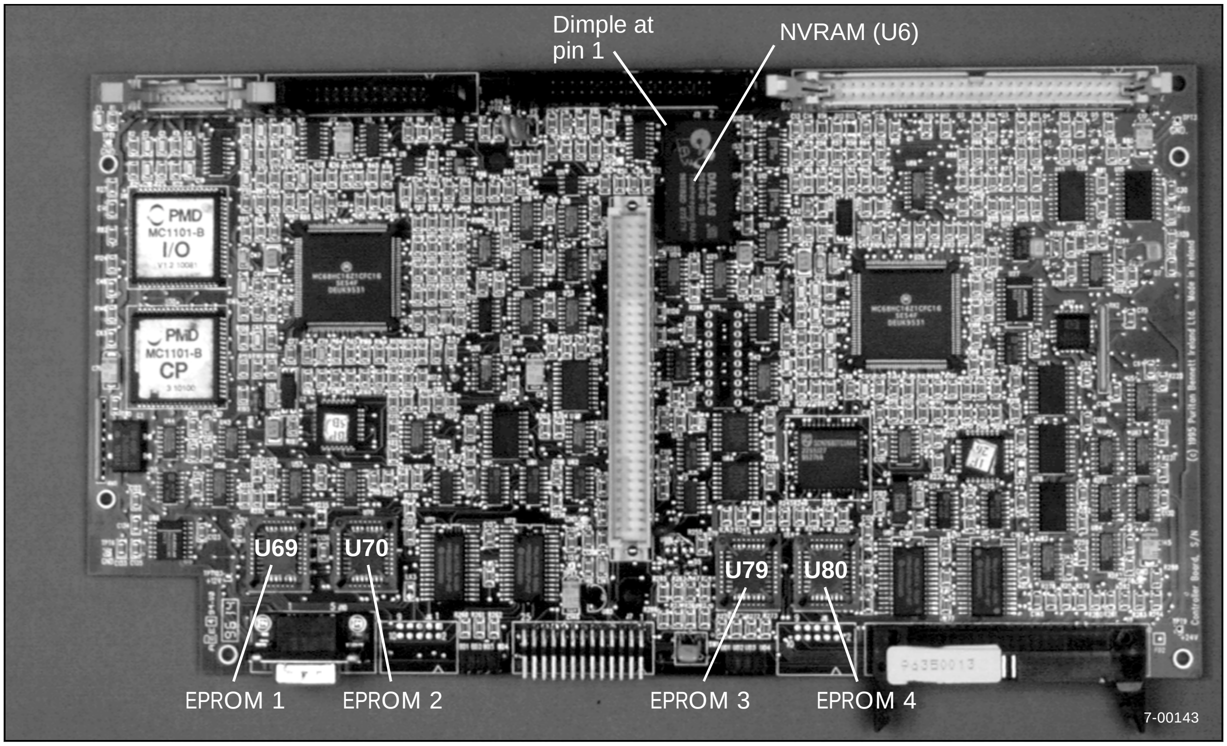


Figure 8-42. Controller PCB component locations

8.10.3.4 Removing/installing NVRAM (Figure 8-42)

Remove the NVRAM (nonvolatile random-access memory) from the controller PCB as follows. Install by reversing removal procedure.

Caution

To prevent ESD damage, always follow ESD guidelines when handling PCBs or NVRAM.

1. Open and prop lid (Section 8.5.1).
2. Disconnect ventilator head harness from upper lefthand corner of pressure solenoid PCB.
3. Using 5-mm nutdriver, remove seven nuts and internal lockwashers that retain pressure solenoid PCB. Lift PCB forward so it rests on speaker.
4. Remove NVRAM (U6), using NVRAM extractor tool (P/N G-061566-00).

NOTE:

- When installing the NVRAM, make sure the dimple located at pin 1 is in the upper lefthand corner.
- When installing a new NVRAM, follow the procedure in Section 8.10.3.5 to update the new NVRAM with ventilator data.

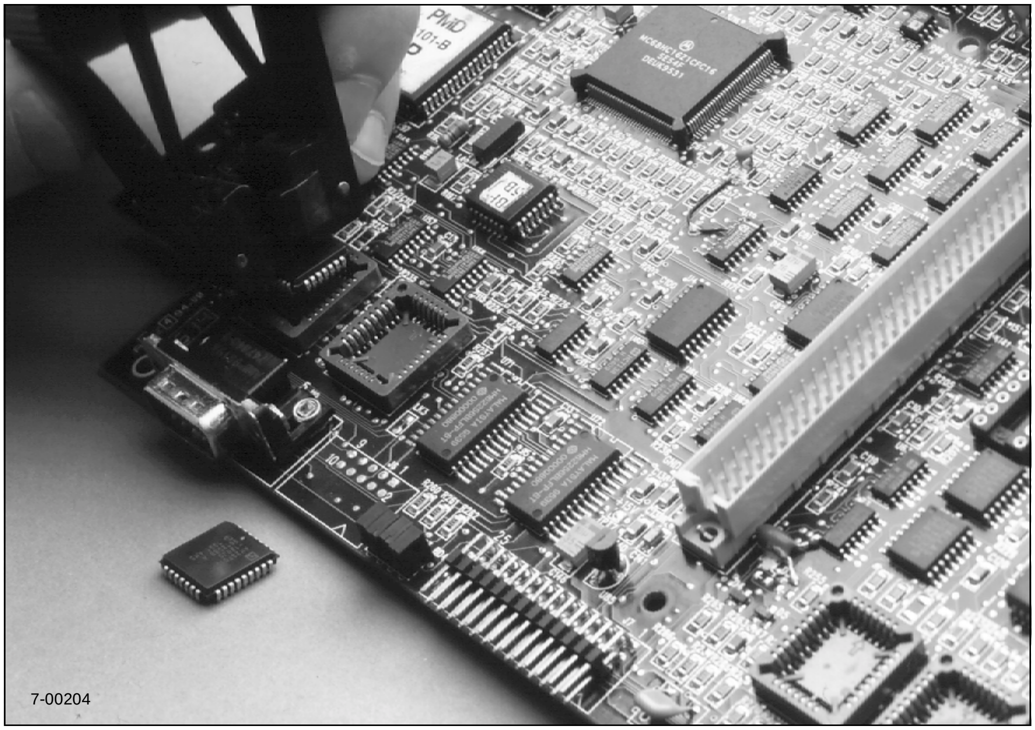
8.10.3.5 Updating NVRAM data

If the NVRAM on the controller PCB fails, install a new NVRAM. After powering on the ventilator, update NVRAM data as follows:

1. Use *Update constants* function in the service menu (Section 4.2.3.5) to update the following calibration constants:
    - Piston
    - Flow sensor
    - Oxygen mixing

   These calibration constants are printed on labels placed inside the ventilator lid.
2. *For ventilators with software revision H or later,* always input the calibration constants of the new pressure solenoid PCB into NVRAM using the *Update prsol nvram* function in the service menu (Section 4.2.3.5). To ensure correct function of the pressure solenoid PCB, you must perform the *Update prsol nvram* function **before** the *O2 pressure calib* and *FIO2 sensor calib* functions.
3. Perform the following calibrations (Section 4.2.3.2.2):
    - PEEP pump
    - Oxygen pressure transducer
    - FIO_2 calibration check.

4. Update the following service information (Section 4.2.3.7):
   - Reset battery in use
   - Reset next service (accept the setting closest to the previous ventilator history)
   - Reset serial number to correspond to the serial number plate.
5. Perform a complete performance verification (Section 5).



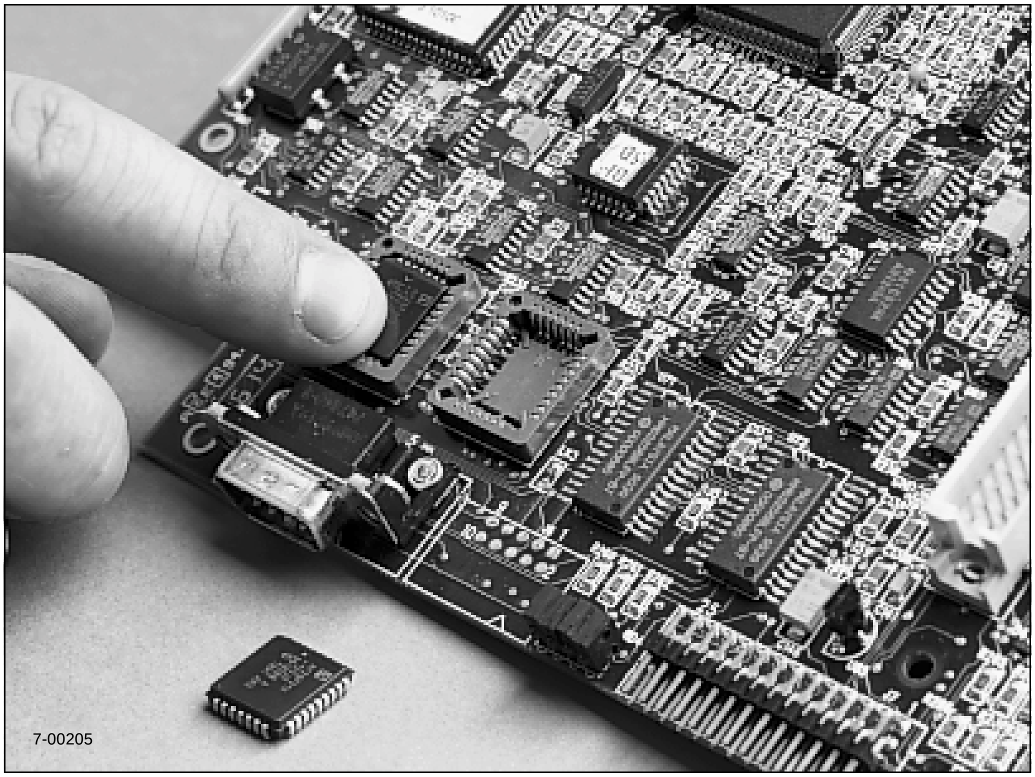


Figure 8-43. Removing and installing EPROMs

8.10.4 Cylinder and exhalation pressure transducer autozero solenoids (Figure 8-40)

Remove the cylinder or exhalation pressure transducer autozero solenoid as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect tubes from applicable solenoid.

Caution

To prevent equipment damage, never disconnect any solenoids while power is applied.

3. Disconnect solenoid harness from ventilator head harness at cable management bar.
4. Using 7/64-in. hex driver, remove two 6-32 x 5/16 POZIDRIV screws and split-ring washers that attach solenoid to cable management bar. Remove solenoid.

NOTE:

When installing the autozero solenoids, orient them with ports pointing upward.

8.10.5 Cable management bar (Figure 8-40)

Remove the cable management bar as follows. Install by reversing removal procedure.

1. Disconnect harnesses and tubes as necessary to remove bar.
2. Using 7-mm nutdriver, remove M4 nut and split-ring washer from bottom of bar.
3. Using 7/64-in. hex driver, remove two 6/32 x 5/16 screws and split-ring washers that retain cylinder pressure transducer autozero solenoid (Section 8.10.4). It is not necessary to disconnect tubing or harness.
4. Using 3-mm hex driver, remove M4 x 8 screw and split-ring washer from top of bar. Remove bar.
5. Complete removal of harnesses and other solenoid.

8.11 PEEP pump and reservoir

8.11.1 PEEP pump (Figure 8-44)

Caution

To prevent equipment damage, never disconnect the PEEP pump while power is applied.

NOTE:

Replace the PEEP pump every 30,000 hours. It is part of the 30,000-hour preventive maintenance kit.

Remove the PEEP pump as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect PEEP pump from ventilator head harness.
3. Disconnect tubing from pump.
4. Using 7-mm nutdriver, remove four M4 nuts and split-ring washers that retain pump to pump tray. Remove pump.

NOTE:

After installing a new PEEP pump, always perform a PEEP pump calibration (Section 4.2.3.2.2).

8.11.2 PEEP reservoir and filter (Figure 8-44)

Remove the PEEP reservoir or filter as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect tubes from pump.
3. Disconnect tube from bottom of exhalation solenoid.
4. Remove filter from front of PEEP reservoir.
5. Clear space to remove reservoir as follows:
   a. Remove main fan to provide opening for reservoir to be removed (Section 8.13.1).
   b. Disconnect tubes or harnesses as needed.
6. Using 3-mm hex driver, remove two M4 x 8 screws and split-ring washers from top of PEEP pump tray. Remove reservoir through fan opening.

NOTE:

When installing the filter, orient it so the filter inlet (written on filter) faces outward.

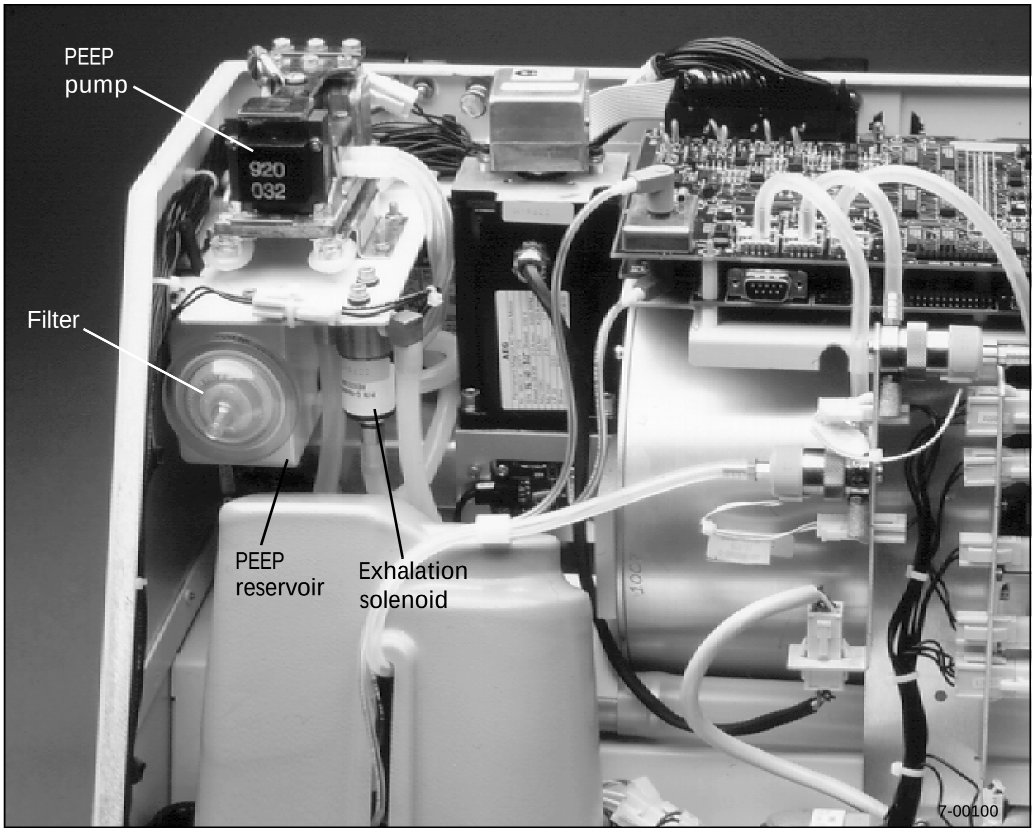


Figure 8-44. PEEP pump and reservoir

8.11.3 Exhalation solenoid (Figure 8-44)

Remove the exhalation solenoid as follows. Install by reversing removal procedure.

NOTE:

Replace the exhalation solenoid every 15,000 hours. It is part of the 15,000- and 30,000-hour preventive maintenance kits.

---

1. Open and prop lid (Section 8.5.1).

Caution

To prevent equipment damage, never disconnect any solenoids while power is applied.

2. Disconnect solenoid harness from ventilator head harness.
3. Disconnect tubes from solenoid.
4. Using 3-mm hex driver, remove two M4 x 14 screws and flat washers that attach solenoid to PEEP pump tray. Remove solenoid.

NOTE:

When installing the exhalation solenoid, make sure the elbow marked EXH faces to the left and the elbow marked CYL faces to the right.

8.12 Piston/cylinder and motor/encoder assemblies

Caution

Never attempt to open up the piston/cylinder assembly. Opening up the piston/ cylinder may allow debris into the cylinder, causing damage.

8.12.1 Optoswitches (Figure 8-45)

Remove the optoswitches as follows. Install by reversing removal procedure.

1. Remove exhalation assembly (Section 8.9.2).
2. Remove options panel plate (Section 8.6.2).
3. Disconnect main ventilator head harness from optoswitch.
4. Using 1.5-mm hex driver, remove four M3 x 8 screws and split-ring washers per optoswitch. Remove optoswitch.

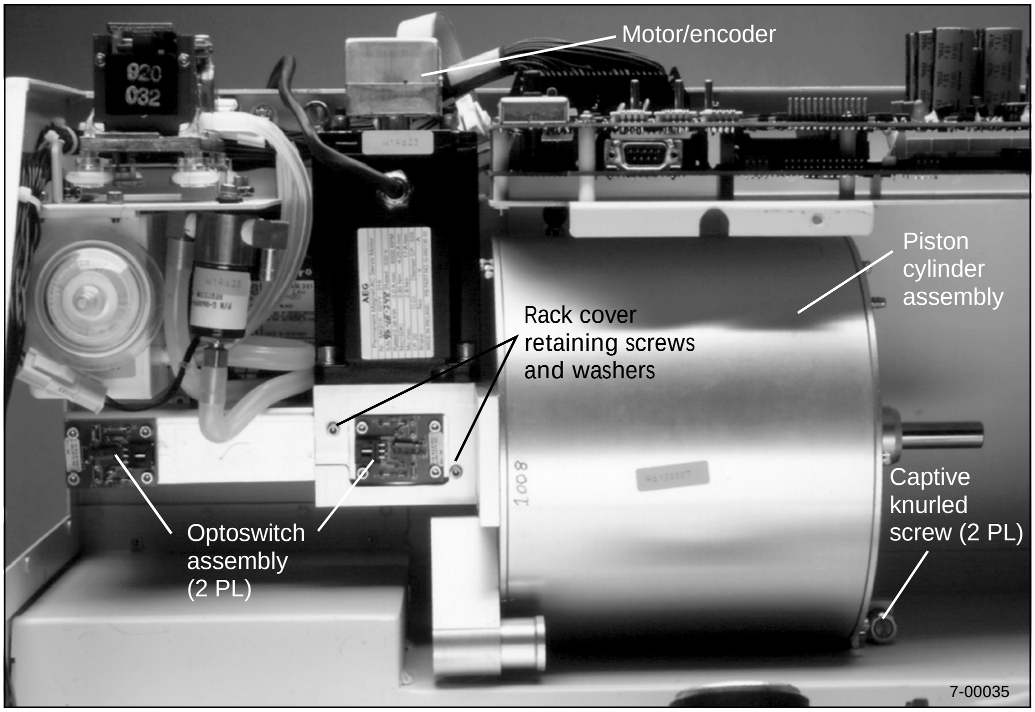

Motor/encoder
Piston cylinder assembly
Rack cover retaining screws and washers
Captive knurled screw (2 PL)
Optoswitch assembly (2 PL)
7-00035

Figure 8-45. Piston/cylinder assembly installed

8.12.2 Removing/installing piston/cylinder and motor/encoder assemblies (Figure 8-45)

Remove the piston/cylinder and motor/encoder assemblies (with inspiration manifold assembly), as follows. Install by reversing removal procedure.

1. Open and prop lid (Section 8.5.1).
2. Remove inspiration access panel and air intake manifold assembly (Section 8.6.6).

3. Remove oxygen regulator and oxygen solenoid assembly (Section 8.7, steps 1 through 4).
4. Remove exhalation assembly (Section 8.9.3).
5. Remove cable management bar partially, to clear space for piston/cylinder removal (Section 8.10.5).
6. Disconnect tubing and harnesses as required to gain access to cylinder.
7. Using flat-bladed screwdriver with a long shank, loosen two captive knurled screws located at either side of cylinder on bottom.
8. Using 4-mm hex driver, remove one M5 x 12 screw, flat washer, and split-ring washer from back of ventilator, just to left of fan. Lift out piston/cylinder assembly.
9. Remove inspiration manifold assembly from piston/cylinder assembly (Section 8.8.4, step 5).
10. Remove mixing manifold assembly from piston/cylinder assembly (Section 8.7, step 7).
11. Using 4-mm hex driver, remove motor/encoder by removing four M5 x 20 screws, flat washers, and split-ring washers.
12. If desired, remove rack cover by using 2.5-mm hex driver to remove three M3 x 12 screws and split-ring washers (two are shown in Figure 8-45).

Caution

Always perform the gear mesh procedure (Section 8.12.4) to reinstall the motor/encoder to the piston/cylinder assembly. The failure to perform this procedure properly may result in damage to the piston/cylinder assembly.

NOTE:

When installing a new piston/cylinder assembly, always do the following: (1) input the calibration constants of the new assembly into NVRAM (Section 4), (2) install calibration constants label supplied over existing "PUMP ASSEMBLY" section of calibration constants label on underside of ventilator lid, (3) grease the rack, and (4) perform the gear mesh procedure.

8.12.3 Greasing rack (Figure 8-46)

Grease the rack every 15,000 hours and every time you install a new piston/cylinder assembly; rack grease is part of the 15,000- and 30,000-hour preventive maintenance kits.

The rack can be greased with or without the piston/cylinder assembly removed from the ventilator. Figure 8-46 shows the piston/cylinder assembly removed. Before greasing rack, manipulate piston so rack is in its fully extended position. Use a clean, lint-free cloth to remove surface grease, if applicable. Inspect the rack and pinion for wear, chips, or breakage. Brush grease onto the rack teeth evenly over the length of the rack. Push piston back and forth to evenly distribute grease. Wipe off excess grease.

Caution

Make sure there is no grease on the optoswitches and rack flag. Grease on the optoswitches in particular can cause the ventilator to malfunction.

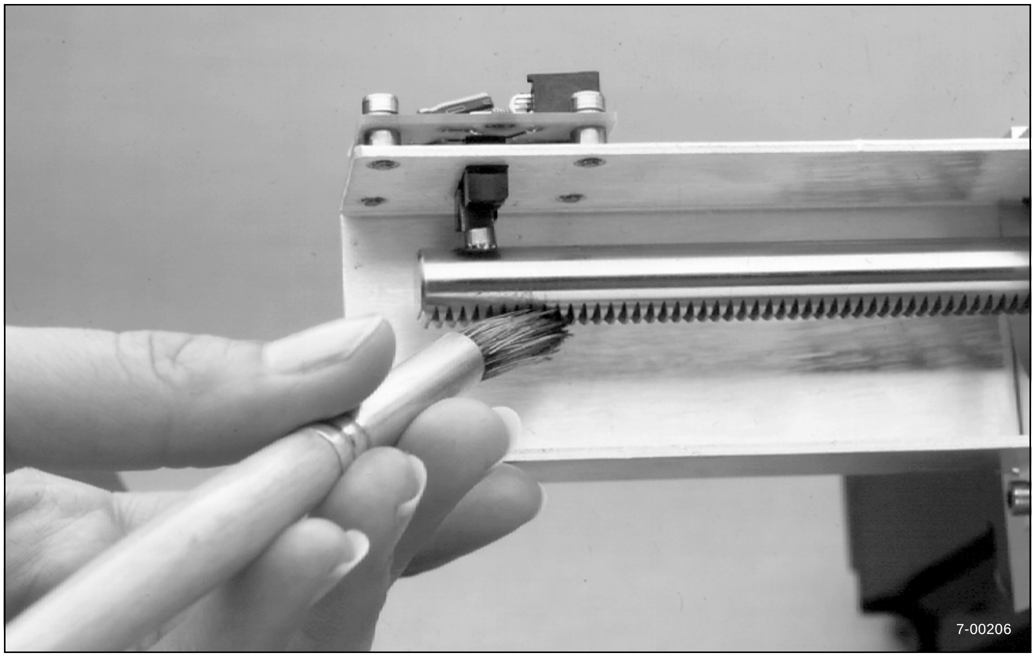


Figure 8-46. Greasing rack

8.12.4 Meshing motor pinion gear with rack

Caution

- Always perform the gear mesh procedure to reinstall the motor/encoder to the piston/cylinder assembly. The failure to perform this procedure properly may result in damage to the piston/cylinder assembly.
- Be extremely careful to prevent debris of any kind from entering the cylinder while the check valve is off. Debris can permanently damage the piston/cylinder assembly.

NOTE:
- The gear mesh procedure must be performed with the piston/cylinder outside of the ventilator.
- The illustrations accompanying this procedure show the rack cover removed for clarity.

Whenever you install the motor/encoder to the piston/cylinder, you must mesh the motor's pinion gear with the rack. To mesh the gear, do the following:

1. Make sure piston/cylinder is removed from ventilator (Section 8.12.2, steps 1 through 8) and motor/encoder is removed from piston/cylinder.
2. Push rack to its end stop at delivered end (far away from motor) of cylinder (Figure 8-47).

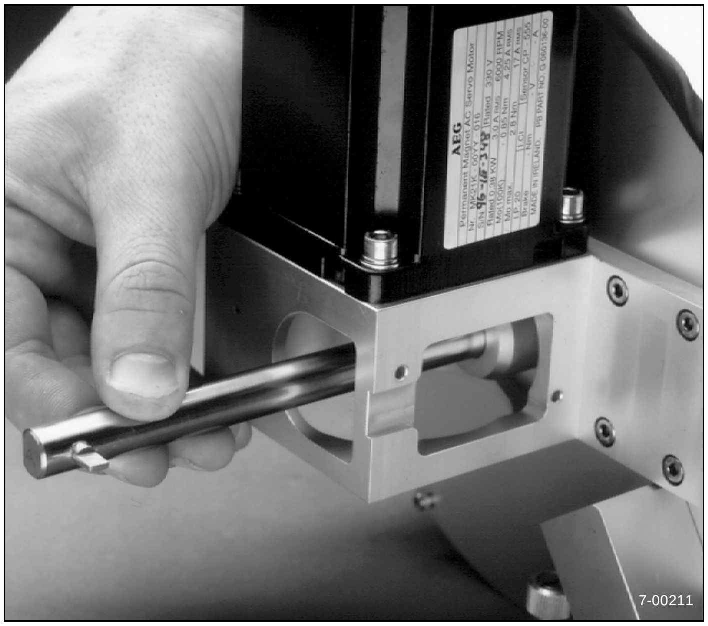


Figure 8-47. Gear mesh procedure: Pushing rack to end stop at delivered end

3. Position motor/encoder on motor angle bracket with pinion facing down (Figure 8-48) and power input cable to motor facing front of cylinder (Figure 8-50).
4. Using 4-mm hex driver, install four M5 x 20 screws, split-ring washers, and flat washers (spring washers located between screw heads and flat washers), but do not tighten them. The screw head should be just above the washers and the split-ring washers should not be in the locked positions (Figure 8-49).
5. Applying firm hand force to center of motor just above angle bracket, force motor into mesh with rack. With hand force still applied, push rack back and forth several times. (This will turn the rack until the rack teeth face and the pinion are aligned parallel.) Visually verify that pinion gear meshes with rack teeth.

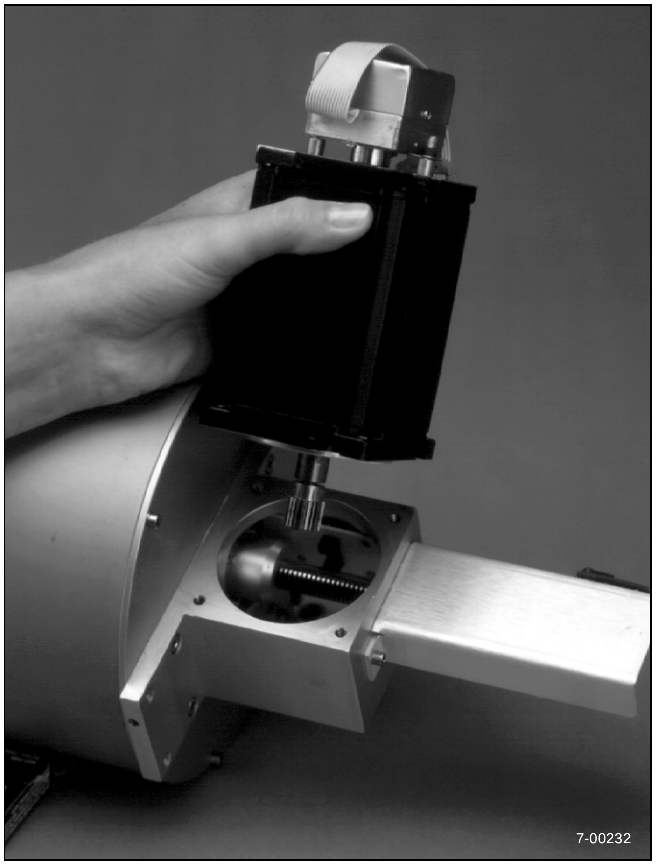


Figure 8-48. Gear mesh procedure: Positioning motor encoder

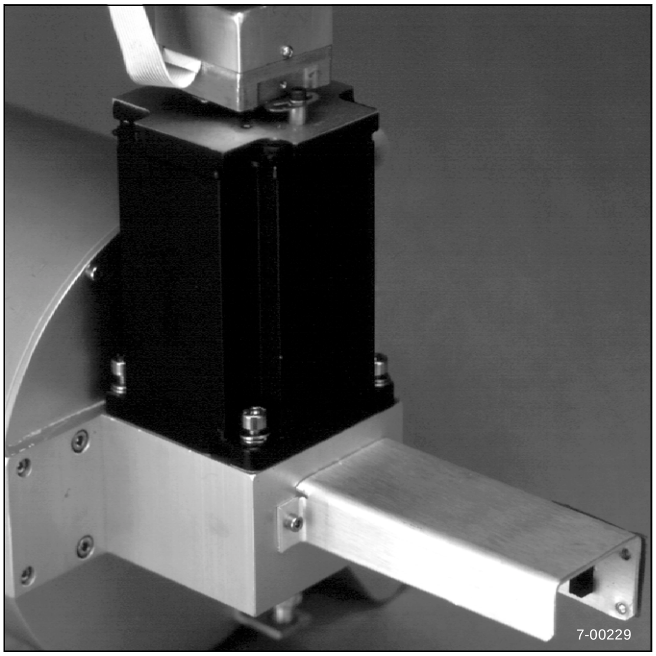


Figure 8-49. Gear mesh procedure: Fasteners installed but not locked

6. With hand force still applied, tighten each screw until it slightly compresses spring washer (Figure 8-50). After all four spring washers are pinched, release meshing force.

NOTE:

At this point, the screws should be tight enough that the motor would not free-fall under its own weight when turned 90 degrees. When the piston/cylinder is upright, however, a firm force applied by two fingers should be enough to move the motor to the end of its screw location slots.

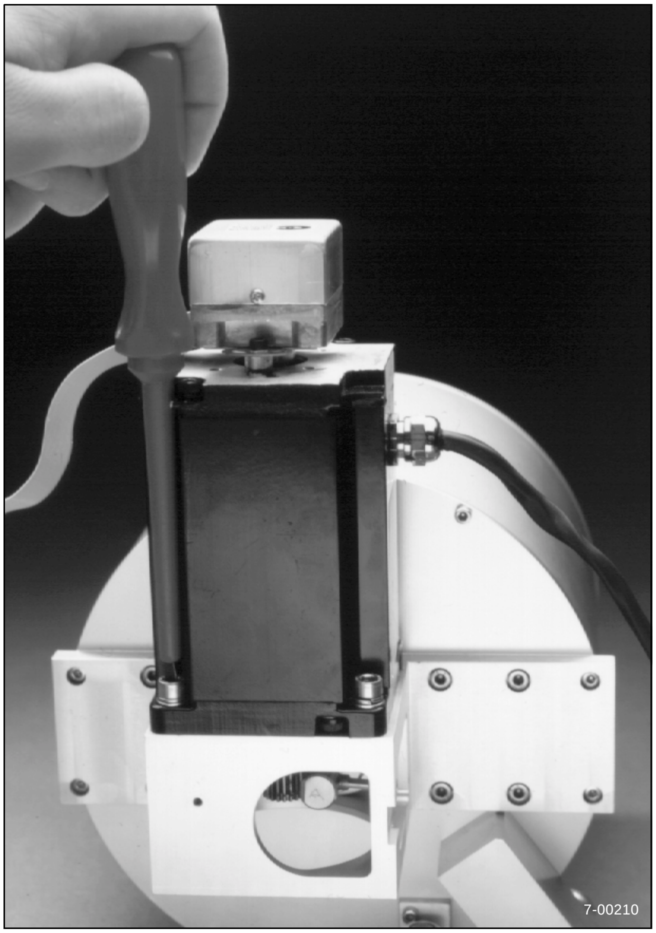


Figure 8-50. Gear mesh procedure: Tightening screws to slightly compress spring washers

7. Use your hand to gently twist plain end of shaft, first in one direction, and then in other. Make sure rack does not rock. Make sure rack flag maintains an even distance between optoswitches and that flag does not interfere with optoswitches when rack is moved back and forth. If you notice rocking, loosen fasteners and repeat procedure from step 5 above. If after repeating procedure gears still are not meshed properly, inspect pinion gear for wear and replace motor/encoder, if necessary.
8. Push rack from its set end stop at delivery end of piston/cylinder to end stop at drive end (Figure 8-51). Push rack back to its original position at same speed. Repeat process five to six times. The motor will be pushed away from the meshing gears so that the mesh now occurs at the highest contact point between rack and pinion.
9. Carefully secure mounting screws, tightening incrementally across the diagonal in three equal increments. Firmly tighten at final increment. As a check, repeat step 7.

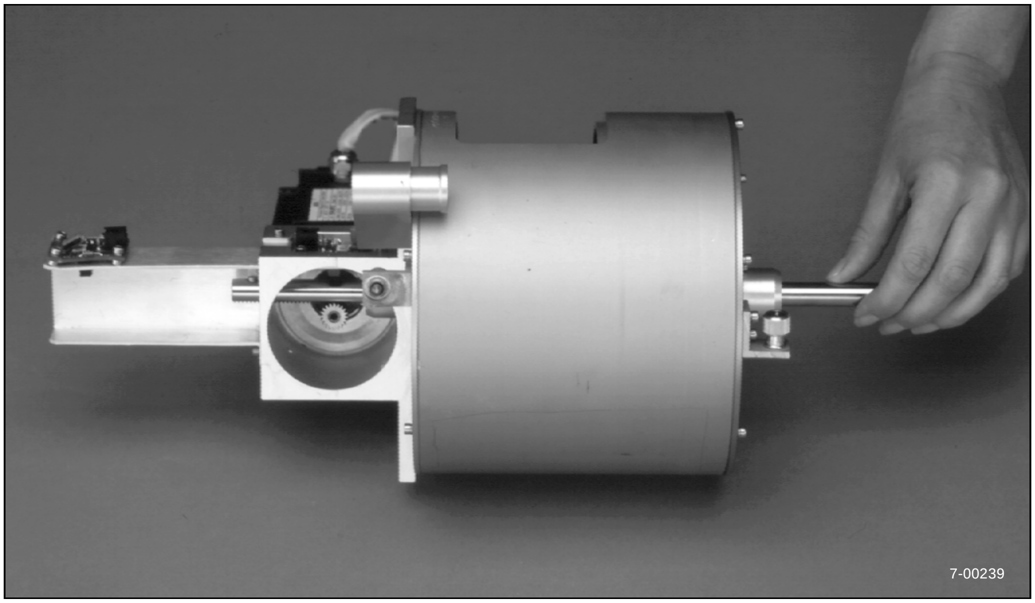


Figure 8-51. Gear mesh procedure: Pushing rack from end to end

8.13 Ventilator rear components

8.13.1 Main fan and filter (Figure 8-52)

NOTE:

- Clean or replace the fan filter every 250 hours (or more frequently if needed). It is also part of the 15,000- and 30,000-hour preventive maintenance kits.
- Replace the fan every 15,000 hours. It is part of the 15,000- and 30,000-hour preventive maintenance kits.

Remove the main fan and filter as follows. Install by reversing removal procedure.

1. Remove fan filter cover by turning two slotted, captive screws. Remove filter. Either vacuum filter; or wash filter in a warm detergent solution, rinse, and dry well; or replace filter.
2. Disconnect fan from ventilator head harness.
3. Remove fan with fan guard by removing four M3 x 8 POZIDRIV screws with captive washers. Pull out fan/fan guard.
4. Using 2.5-mm hex driver, disassemble fan from fan guard by removing four M3 x 10 screws, flat washers, and split-ring washers.

NOTE:

When installing the fan, orient it with the harness at the top and the arrow facing into the unit.

8.13.2 Internal battery (Figure 8-52)

NOTE:

Replace the internal battery as per the battery life remaining viewable through the service summary.

Remove the internal battery as follows. Install by reversing removal procedure.

1. Remove battery compartment access plate by removing four M3 x 12 POZIDRIV screws with captive washers.
2. Slide out battery partway. *D*isconnect harness. Finish sliding out battery.

NOTE:

After installing a new internal battery, reset the battery's hours of use counter (Section 4.2.3.7).

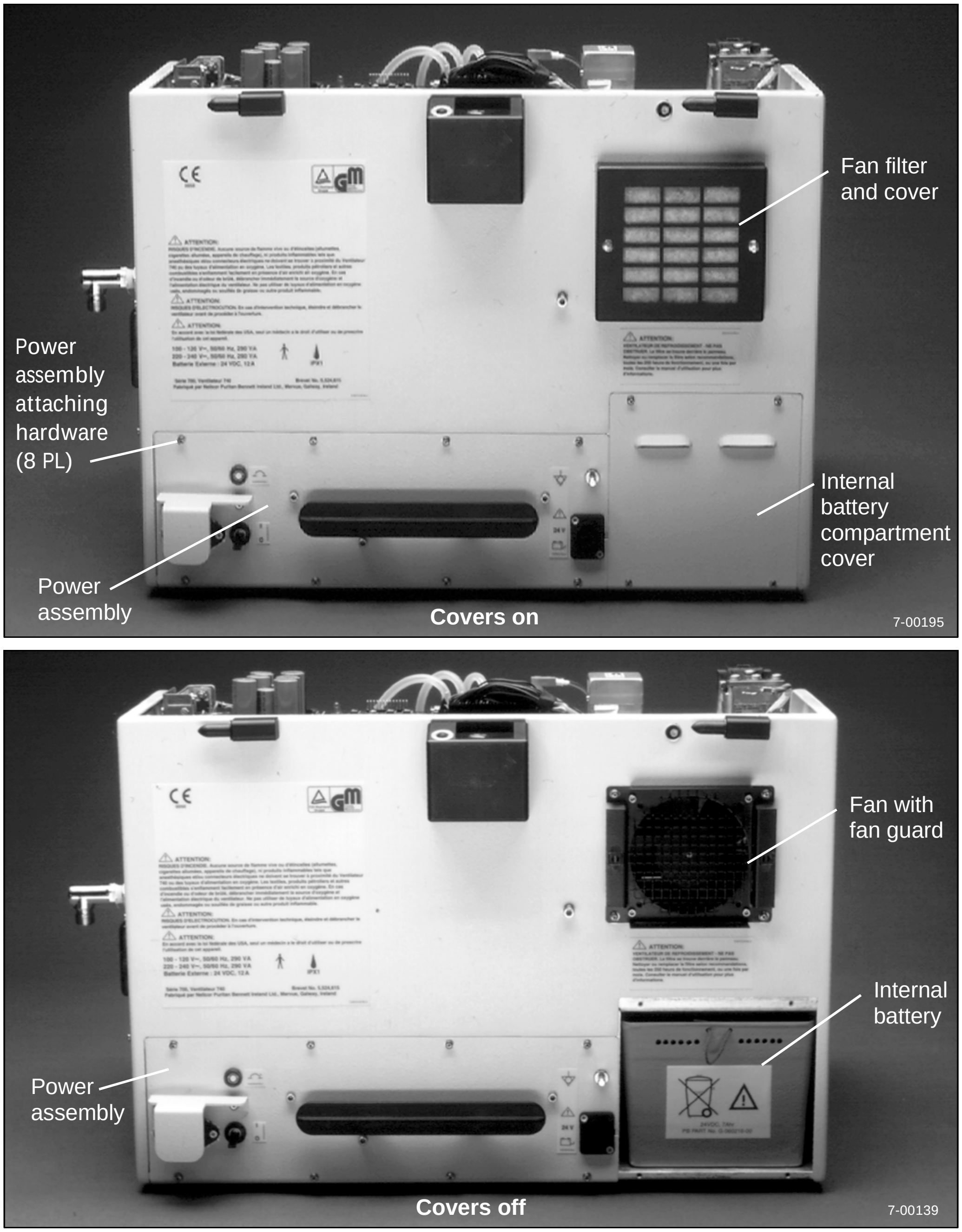

Fan filter and cover
Power assembly attaching hardware (8 PL)
Internal battery compartment cover
Power assembly
Covers on
7-00195
Fan with fan guard
Internal battery
Power assembly
Covers off
7-00139

Figure 8-52. Ventilator rear components

8.14 Power assembly

Warning

To prevent electrical shock hazard, always unplug the power cord from facility power and disconnect the external and internal battery harnesses from the BBU PCB before servicing the power assembly.

Caution

To prevent damage to ESD-sensitive components, always follow ESD guidelines when servicing the power assembly.

8.14.1 Power cord

To gain access to power cord, loosen one M3 x 8 POZIDRIV screw with captive washers, in slot of power cord retainer (Figure 8-53). Swing retainer up. Unplug power cord from line filter.

8.14.2 Removing power assembly

Remove the power assembly components as follows. Install the power assembly by reversing procedure.

1. Open and prop lid (Section 8.5.1).
2. Disconnect BBU (battery backup) PCB/ventilator head harness from controller PCB and cable management bar (motor/encoder connector) (Figure 8-40). Using 2.5-mm hex driver, remove M3 x 8 screw, internal lockwasher, and flat washer that retain harness-retaining tie wrap to air intake manifold.
3. Remove eight M3 x 12 POZIDRIV screws with captive washers that attach power assembly to ventilator (Figure 8-52). Pull out power assembly until it reaches a stop (Figure 8-53).
4. Partially thread harness through cutout and into power assembly compartment.
5. To remove power assembly completely, **lift up at front**. Power assembly will slip clear of stop.
6. Disconnect internal battery harness from BBU PCB.
7. Ease BBU PCB/ventilator head harness completely into power assembly compartment.

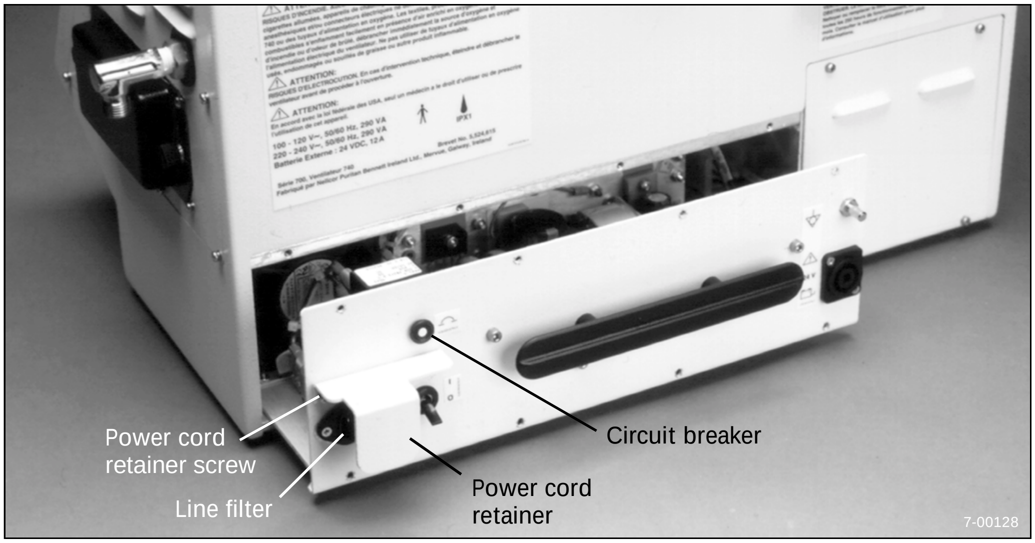

Power cord retainer screw
Line filter
Circuit breaker
Power cord retainer
7-00128

Figure 8-53. Power assembly pulled out

8.14.3 Line filter

Remove the line filter as follows. Install by reversing removal procedure, referring to Figure 9-24 as necessary.

1. Remove power assembly (Section 8.14.2).
2. Disconnect wires from line filter (Figure 8-54).
3. Remove two M3 x 8 flat-head, POZIDRIV screws that secure line filter. Remove line filter.

NOTE:

When installing line filter, make sure ground terminal is at bottom.

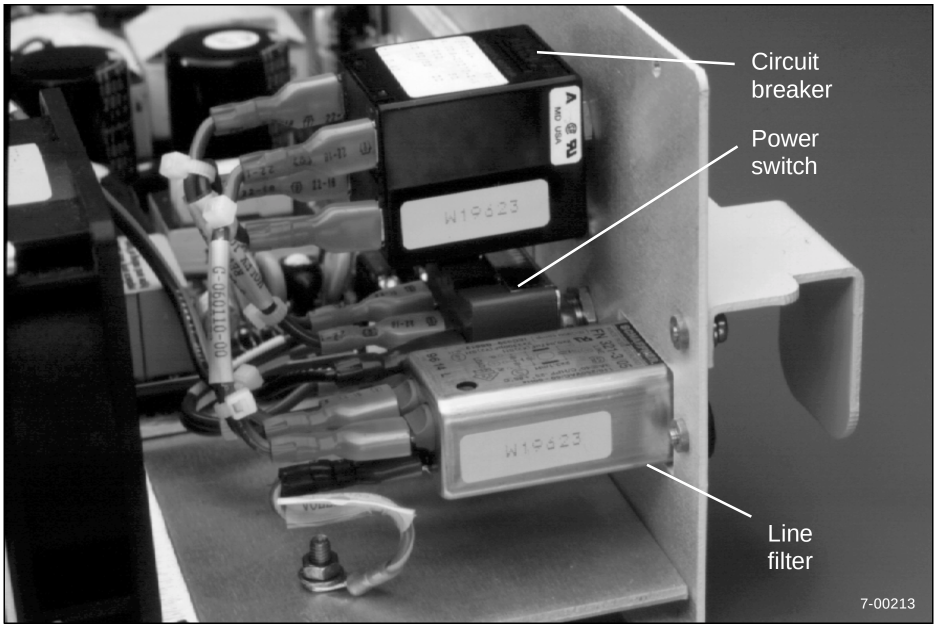

Circuit breaker
Power switch
Line filter
7-00213

Figure 8-54. Line filter, circuit breaker, and power switch connections

8.14.4 Circuit breaker

Remove the circuit breaker as follows. Install by reversing removal procedure, referring to Figure 9-24 as necessary.

1. Remove power assembly (Section 8.14.2).
2. Disconnect wires from circuit breaker terminals (Figure 8-54).
3. Twist off circuit breaker retainer.

Caution

To prevent equipment damage, always replace circuit breaker with correct 4A breaker (P/N G-060033-00).

8.14.5 Power switch

Remove the power switch as follows. Install by reversing removal procedure referring to Figure 9-24 as necessary.

1. Remove power assembly (Section 8.14.2).
2. Disconnect wires from power switch terminals (Figure 8-55).
3. Loosen power switch nut.
4. Remove power switch and retainer.

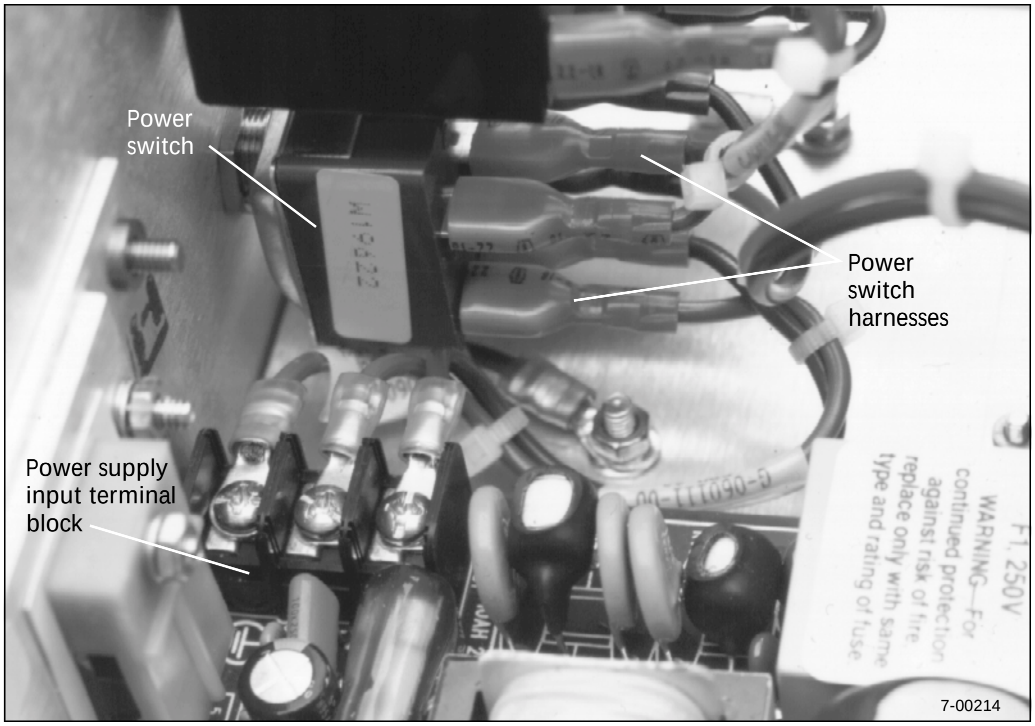


Figure 8-55. Power supply input terminal connections

8.14.6 External battery harness (Figure 8-56)

Remove the external battery harness as follows. Install by reversing removal procedure.

1. Remove power assembly (Section 8.14.2).
2. Open connector cover.
3. Disconnect external battery connector harness from BBU PCB.
4. Remove two M3 x 8 flat-head, POZIDRIV screws that attach harness to power assembly. Pull out harness through cutout in power assembly.

NOTE:

When installing the external battery harness, be sure to attach the ground wires to the chassis with the harness retaining screw.

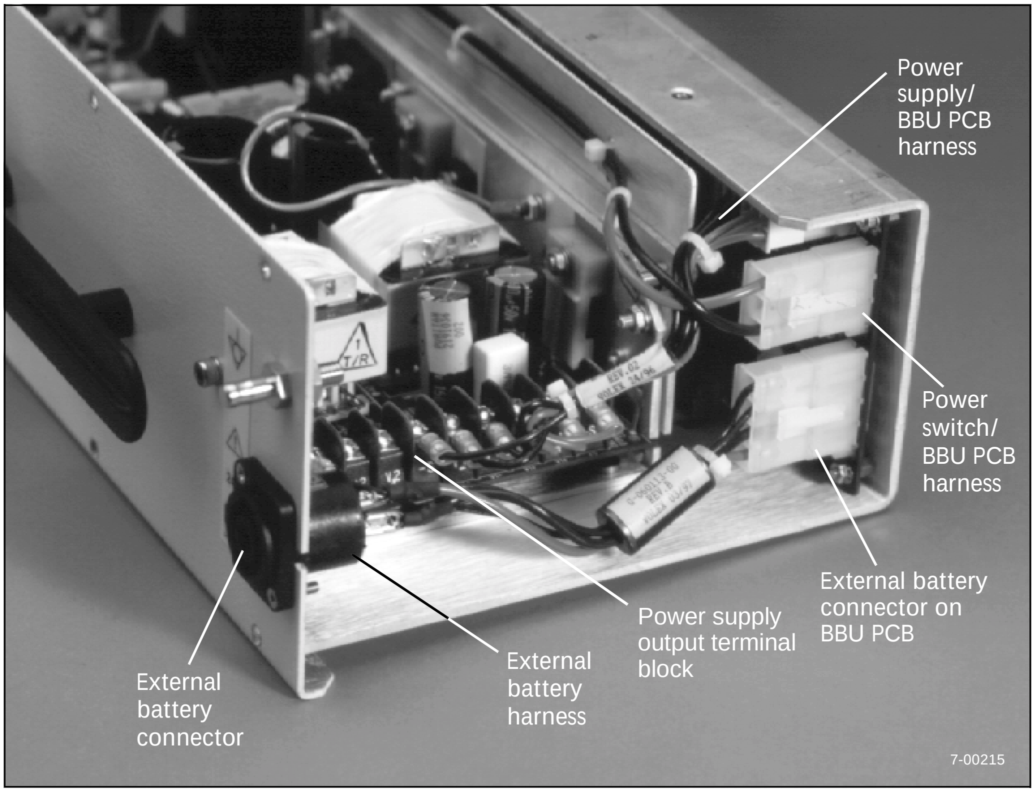

Power supply/ BBU PCB harness
Power switch/ BBU PCB harness
External battery connector on BBU PCB
Power supply output terminal block
External battery harness
External battery connector
7-00215

Figure 8-56. Power supply output terminal connections

8.14.7 Power supply (Figure 8-57)

Remove the power supply as follows. Install by reversing removal procedure, referring to Figure 9-24 as necessary.

Caution

To avoid damaging the ventilator, ensure that the new power supply is labeled with the correct rating (that is, use power supplies labeled **120 VAC** in 100-120 V regions only, or power supplies labeled **120/240 VAC** in 220-240 V regions only) for the ventilator.

1. Before installing a new power supply, verify that it has the correct voltage rating. Refer to Section 9.19 for the correct power supply part number.
2. Remove power assembly (Section 8.14.2).
3. Disconnect power switch/BBU PCB harness from BBU PCB (Figure 8-56) and power switch (Figure 8-55).
4. Disconnect power supply/BBU PCB harness from BBU PCB (Figure 8-56).
5. Remove three screws, and disconnect power switch harness from lefthand terminal block on power supply (power supply input) (Figure 8-55).
6. Using 3-mm hex driver, remove three M4 x 12 screws and split-ring washers that attach power supply to power assembly back panel.
7. From bottom of power assembly, remove four M4 x 6 flat-head, POZIDRIV screws.
8. Lift out power supply.

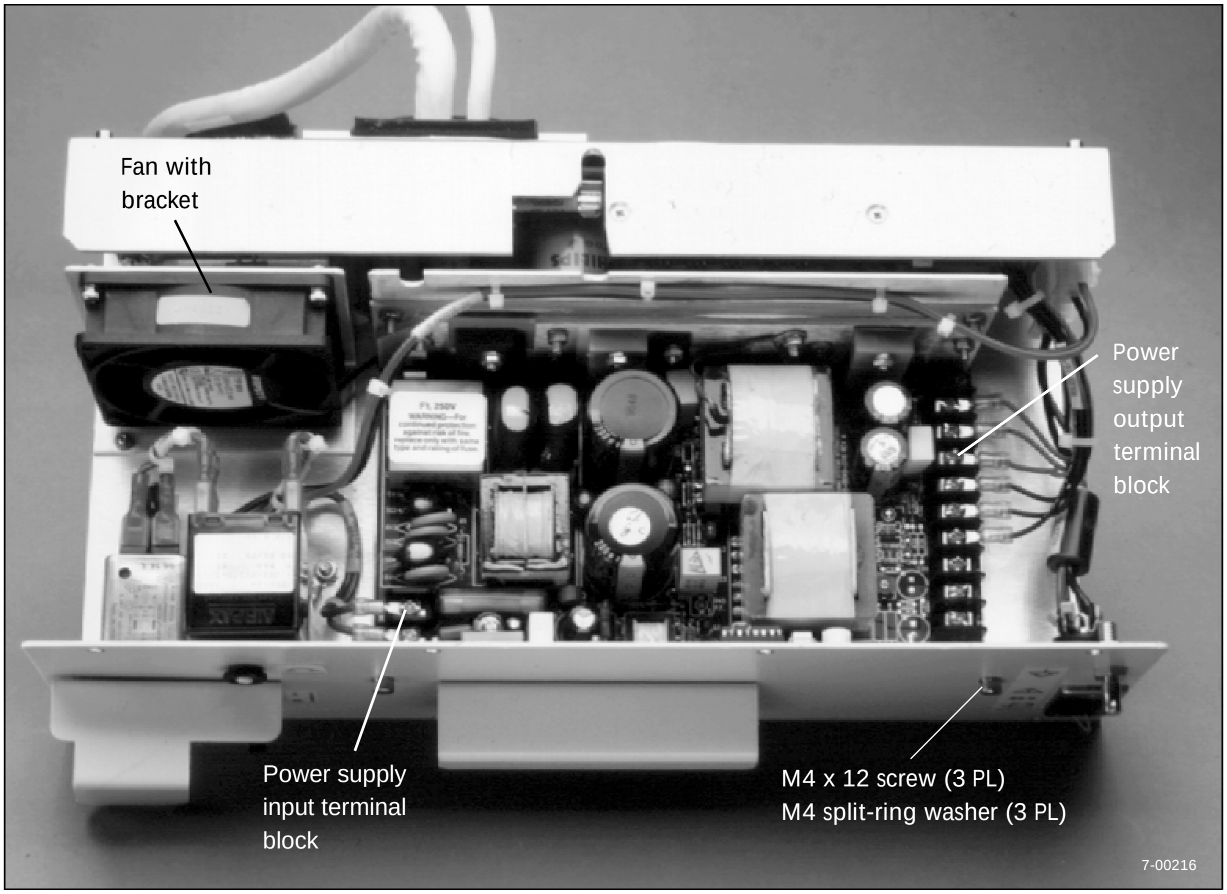

Fan with bracket
Power supply output terminal block
Power supply input terminal block
M4 x 12 screw (3 PL)
M4 split-ring washer (3 PL)
7-00216

Figure 8-57. Power assembly removed

9. Using 3-mm hex driver, remove two M4 x 12 screws and split-ring washers that attach baffle to power supply (Figure 8-58). Remove baffle.
10. Remove six screws, and disconnect power supply/BBU PCB harness from righthand terminal block on power supply (power supply output) (Figure 8-56). Transfer harness to new power supply, as applicable.

NOTE:

- Reinstall existing baffle on new power supply. Failing to reinstall the baffle could hamper proper air circulation, overheating power supply.
- When connecting BBU PCB/power supply harness to righthand terminal block, attach three red wires to top three terminals. Attach three black wires to the next three terminals. Any of the three black wires may go to any of the three positions. Any of the three red wires may go to any of the three positions.
- When reinstalling power supply ground wire, install fasteners in this order: external lockwasher beneath wire, flat washer, then nut.

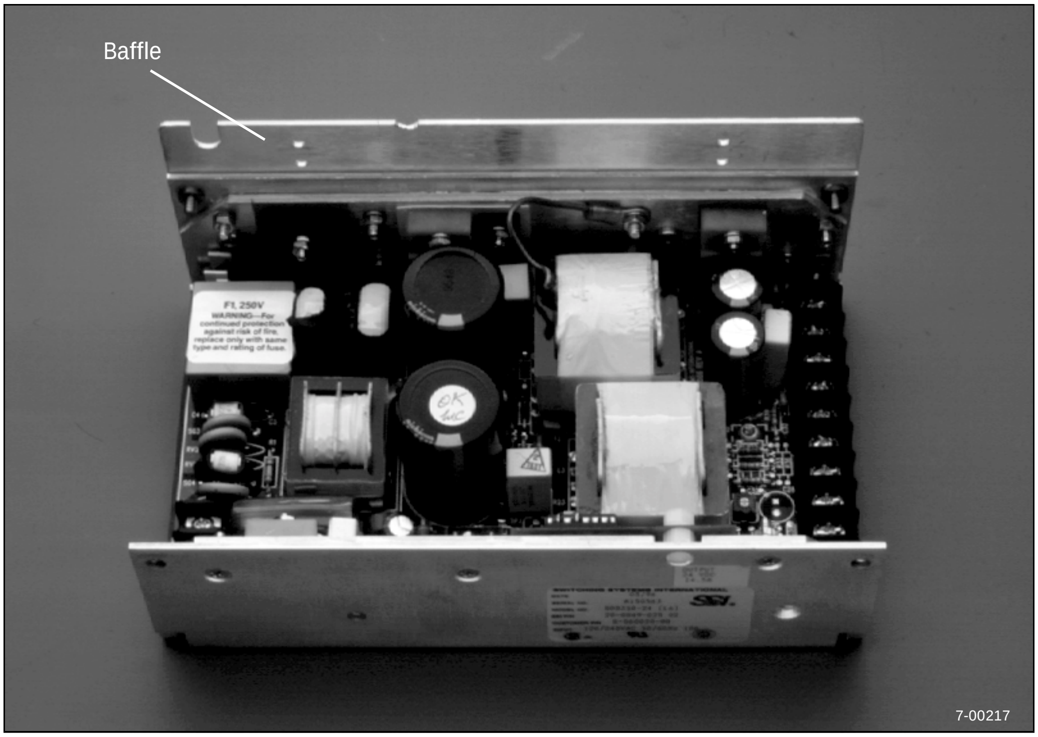

Baffle
7-00217

Figure 8-58. Power supply baffle

8.14.8 Power supply fan (Figure 8-59)

NOTE:

Replace the fan every 15,000 hours. It is part of the 15,000- and 30,000-hour preventive maintenance kits.

Remove the power supply fan as follows. Install by reversing removal procedure.

1. Remove power supply, but do not remove baffle (Section 8.14.7).
2. Disconnect fan harness from BBU PCB.
3. From beneath power assembly, remove two M3 x 8 flathead POZIDRIV screws that attach fan/bracket to base. Remove fan/bracket.
4. Using 2.5-mm hex driver, remove four M3 x 8 screws, split-ring washers, and flat washers; separate fan from bracket.

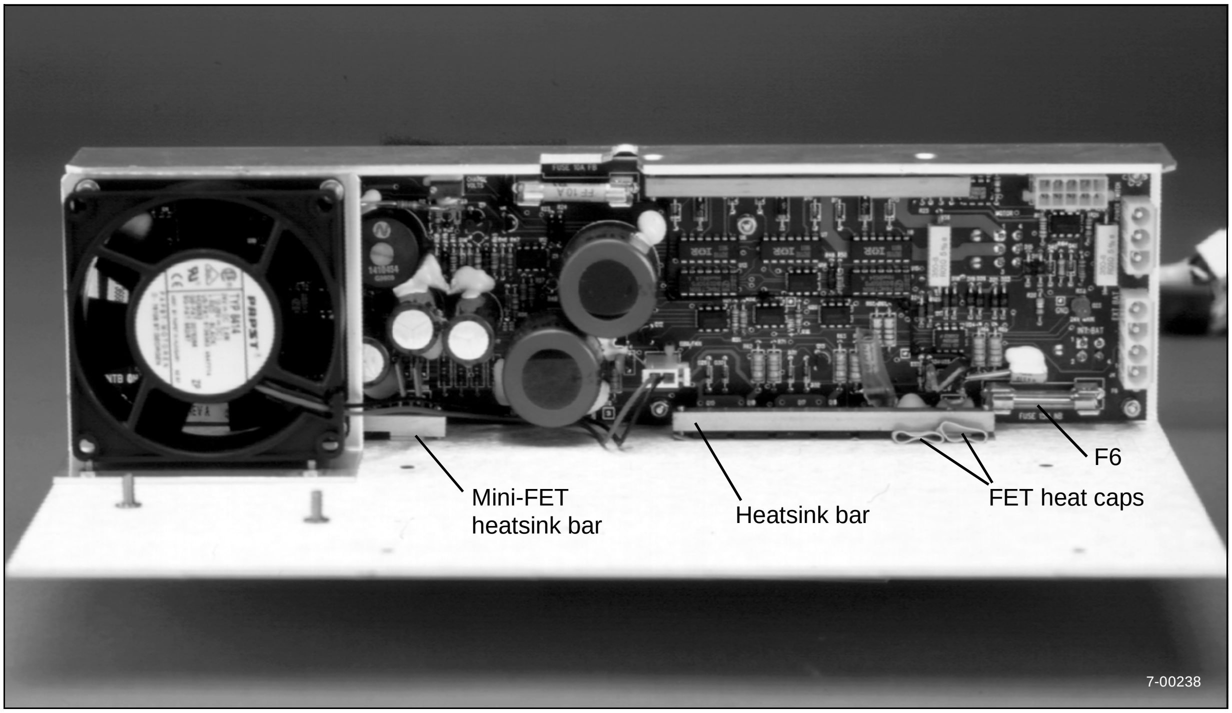


Figure 8-59. BBU PCB and power supply fan

8.14.9 BBU PCB and heatsink bars (Figure 8-59)

Remove the BBU PCB and heatsink bars as follows.

1. Remove power supply (Section 8.14.7).
2. Disconnect all harnesses from PCB (both front and rear).
3. Remove two M3 x 12 flat-head, POZIDRIV screws that retain each heatsink bar (full-size bars at top and bottom of PCB, plus mini-FET heatsink bar) (Figure 8-60).

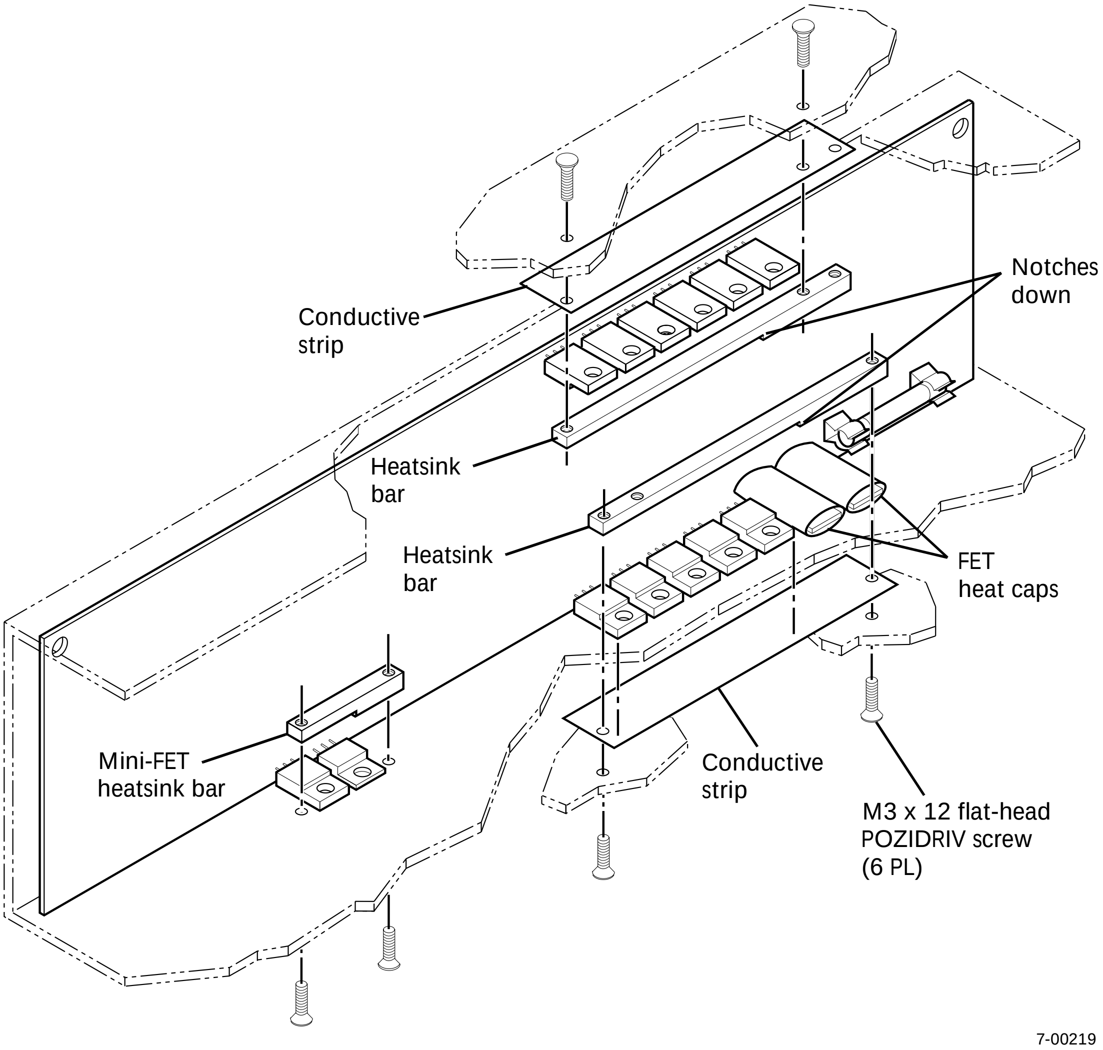

Notches down
Conductive strip
Heatsink bar
Heatsink bar
FET heat caps
Mini-FET heatsink bar
Conductive strip
M3 x 12 flat-head POZIDRIV screw (6 PL)
7-00219

Figure 8-60. Heatsink bars and conductive strips on BBU PCB

4. Using 7/32-in. or 5.5-mm nutdriver, remove six M3 nuts and split-ring lockwashers that retain PCB (Figure 8-61). Lift PCB out.

Install BBU PCB and heatsink bars by reversing removal procedure. Orient heatsink bars and install conductive strips and FET caps, as shown in Figure 8-60.

Caution

When installing the BBU PCB, remember to install the conductive strips between the heatsink bars and power assembly, and be sure the FET caps are in place. If the conductive strips and caps are not installed, the BBU PCB **will** be damaged.

- To prevent damage to the BBU PCB, make sure the FET bars are oriented as shown in Figure 8-60.

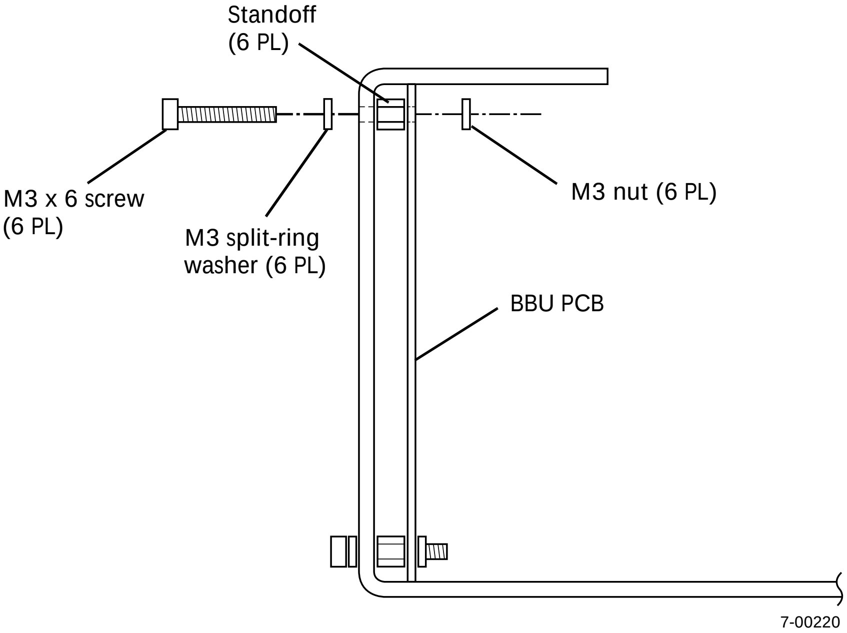


Figure 8-61. BBU PCB attaching hardware

8.14.9.1 Fuses (Figure 8-59)

Caution

To prevent equipment damage, always replace fuses with those of the correct rating and type (see Section 9).

The BBU PCB has two replaceable fuses, which are accessible without removing the PCB. Replace the fuses by gaining access to power assembly (Section 8.14.2, steps 1 through 3), then removing and replacing them as necessary.

8.15 Harnesses and wiring

8.15.1 Main ventilator head harness

Install the main ventilator head harness as follows.

1. Open and prop lid (Section 8.5.1).
2. Route harness as shown in Figure 8-62. The harness goes between the ventilator wall and the cable retainers. The harness connections are shown in Figure 8-63.

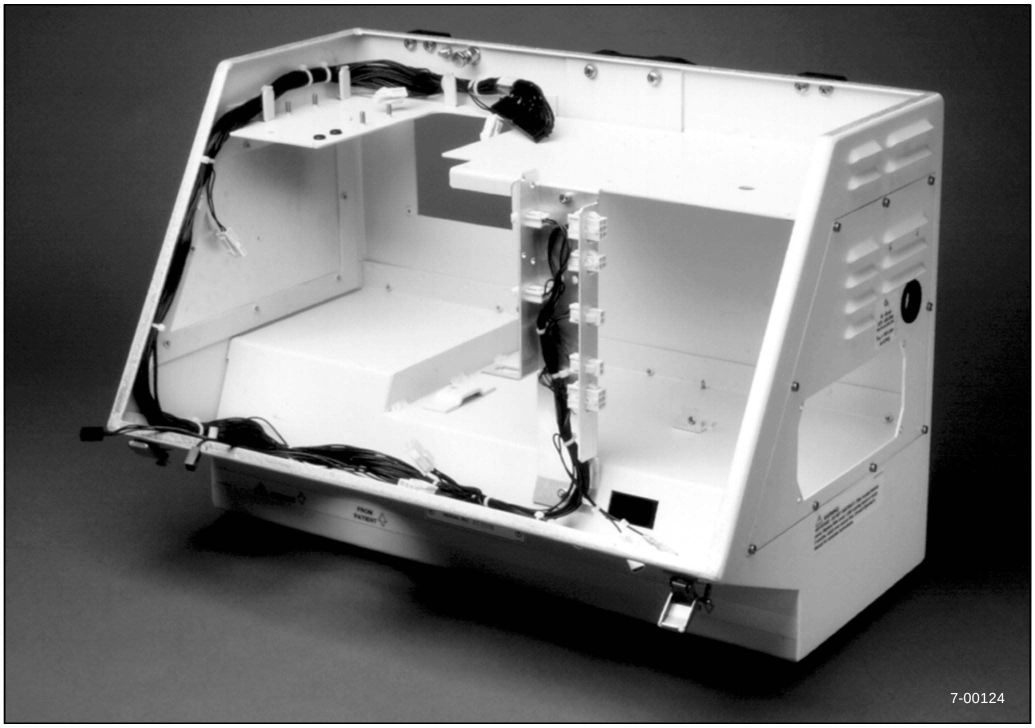


Figure 8-62. Main ventilator head harness installed

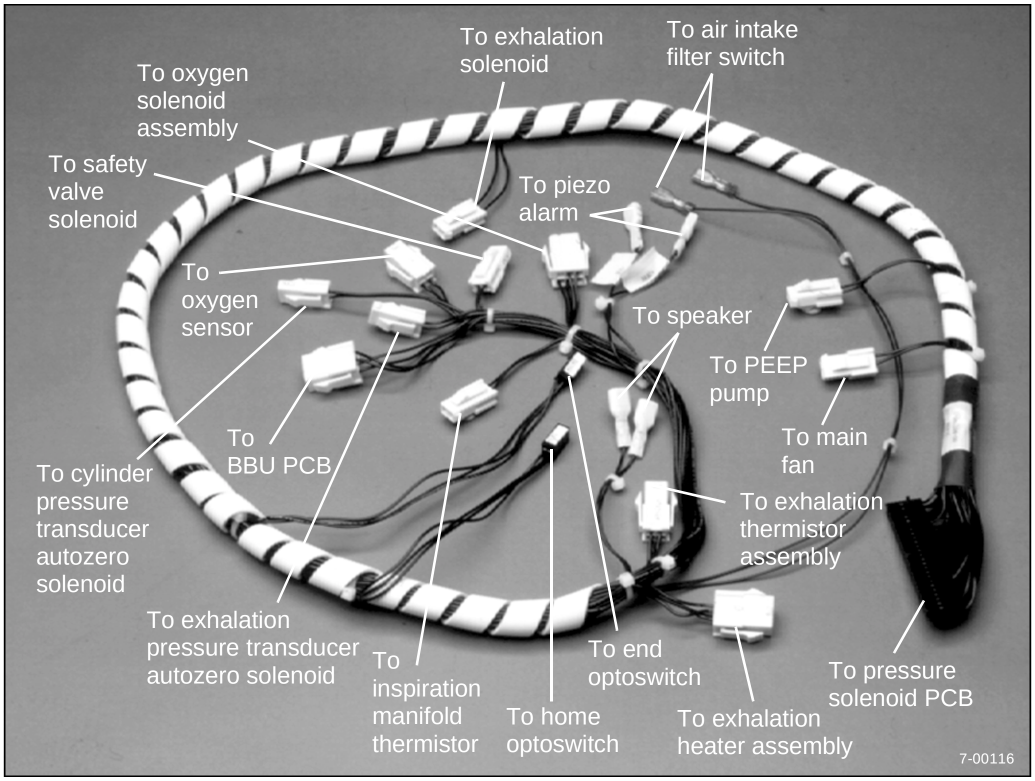

To exhalation solenoid
To air intake filter switch
To oxygen solenoid assembly
To safety valve solenoid
To piezo alarm
To oxygen sensor
To speaker
To PEEP pump
To BBU PCB
To main fan
To cylinder pressure transducer autozero solenoid
To exhalation thermistor assembly
To exhalation pressure transducer autozero solenoid
To inspiration manifold thermistor
To end optoswitch
To home optoswitch
To exhalation heater assembly
To pressure solenoid PCB
7-00116

Figure 8-63. Main ventilator head harness connections

Parts list

9.1 How to use this parts list

This section begins by showing the entire ventilator system, including accessories. Subsequent figures show ventilator subassemblies and their component parts. At the end of the parts list are ventilator tubing and wiring diagrams, followed by preventive maintenance kit contents. Alphabetic and numeric part indexes at the end of the book can help guide you to desired parts.

This section uses the following conventions:

- Two dashes (--) in the *Part no.* column indicate that the part is not orderable and/or shown for reference.
- Bullets (•) in the *Description* column indicate level of indentation. For example, a part with a nonbulleted description includes all the subsequent single-bulleted parts. A part with a single-bulleted description includes all the subsequent double-bulleted (• •) parts, and so on.
- Abbreviations and acronyms used in this section are listed in Table 9-1.

Table 9-1: Abbreviations used in parts list

Abbreviation	Meaning
A/R	as required
BBU	battery backup
cmH_2O	centimeters of water
DISS	diameter index safety system
EPROM	erasable programmable read-only memory
EX LK	external lock
FH	flat-head
HEX	hexagonal
ID	inside diameter
IN LK	internal lock
NIST	non-interchangeable screw thread
NVRAM	nonvolatile random-access memory
OD	outside diameter
PAN	panhead
PCB	printed circuit board
PEEP	positive end expiratory pressure
P/N	part number
SOC	socket
SR	split-ring
UI	user interface

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9.2 *700 Series Ventilator System* patient system and accessories parts list

***700 Series Ventilator System* patient system and accessories**

Item no. (Figure 9-1)	Part no.	Quantity	Description
--	--	--	700 Series Ventilator System
1	4-032006-00	1	• Flex arm assembly (shown in Section 9.4)
2	--	1	• Ventilator breathing circuit (Contact your Nellcor Puritan Bennett representative for ordering information.)
3	4-074600-00	1	• Filter, inspiratory, reusable (*Re/Flex*™ inspiratory bacteria filter, with 22-mm ISO connectors)
	4-074601-00	1	• Filter, inspiratory, disposable (*D/Flex*™ inspiratory bacteria filter, with 22-mm ISO connectors) (package of 12)
4	G-060526-00	1	• Filter, expiratory, disposable (D/X7 ™ expiratory bacteria filter, with 22-mm ISO connectors) (package of 12)
	G-060525-00	1	• Filter, expiratory, reusable (*Re/Flex*™ expiratory bacteria filter, with 22-mm ISO connectors) (use this number outside of North America)
	4-074600-00	1	• Filter, expiratory, reusable (*Re/Flex*™ expiratory bacteria filter, with 22-mm ISO connectors) (use this number in North America)
5	G-061668-00	1	• Collector vial kit
6	--	1	• • Collector vial
7	G-061441-00	1	• • Tube, adult, 15-cm (Connects collector vial to expiratory filter)
8	--	1	• Humidifier kit, Fisher & Paykel MR730 (not available in North America; contact your local sales representative for ordering information)
9	--	1	• Hose assembly, oxygen (See Section 9.3 for parts breakdowns.)
10	--	1	• Power cord (See Section 9.20 for part numbers.)
11	G-061140-00	1	• Battery kit, external (not shown) (see Section 9.6 for parts breakdown.)

700 Series Ventilator System patient system and accessories (continued)

Item no. (Figure 9-1)	Part no.	Quantity	Description
12	G-061260-00	1	• External battery charger, 110 V, for North America/ Japan, with integral power cord (not shown)
	G-061261-00	1	• External battery charger, 220 V, for Australia, with integral power cord (not shown)
	G-061500-00	1	• External battery charger, 220/240 V, for continental Europe, with detachable power cord (not shown)
	G-061501-00	1	• External battery charger, 220/240 V, for Denmark, with detachable power cord (not shown)
	G-061504-00	1	• External battery charger, 220/240 V, for India/South Africa, with detachable power cord (old, British-style plug with round prongs) (not shown)
	G-061505-00	1	• External battery charger, 220/240 V, for Israel, with detachable power cord (not shown)
	G-061502-00	1	• External battery charger, 220/240 V, for Italy, with detachable power cord (not shown)
	G-061503-00	1	• External battery charger, 220/240 V, for Switzerland, with detachable power cord (not shown)
	G-061499-00	1	• External battery charger, 220/240 V, for United Kingdom, with detachable power cord (not shown)
13	G-061627-00	1	• Adapter, humidifier electrical (Goes between Fisher & Paykel humidifier and single-patient use ventilator breathing circuit) (not shown)

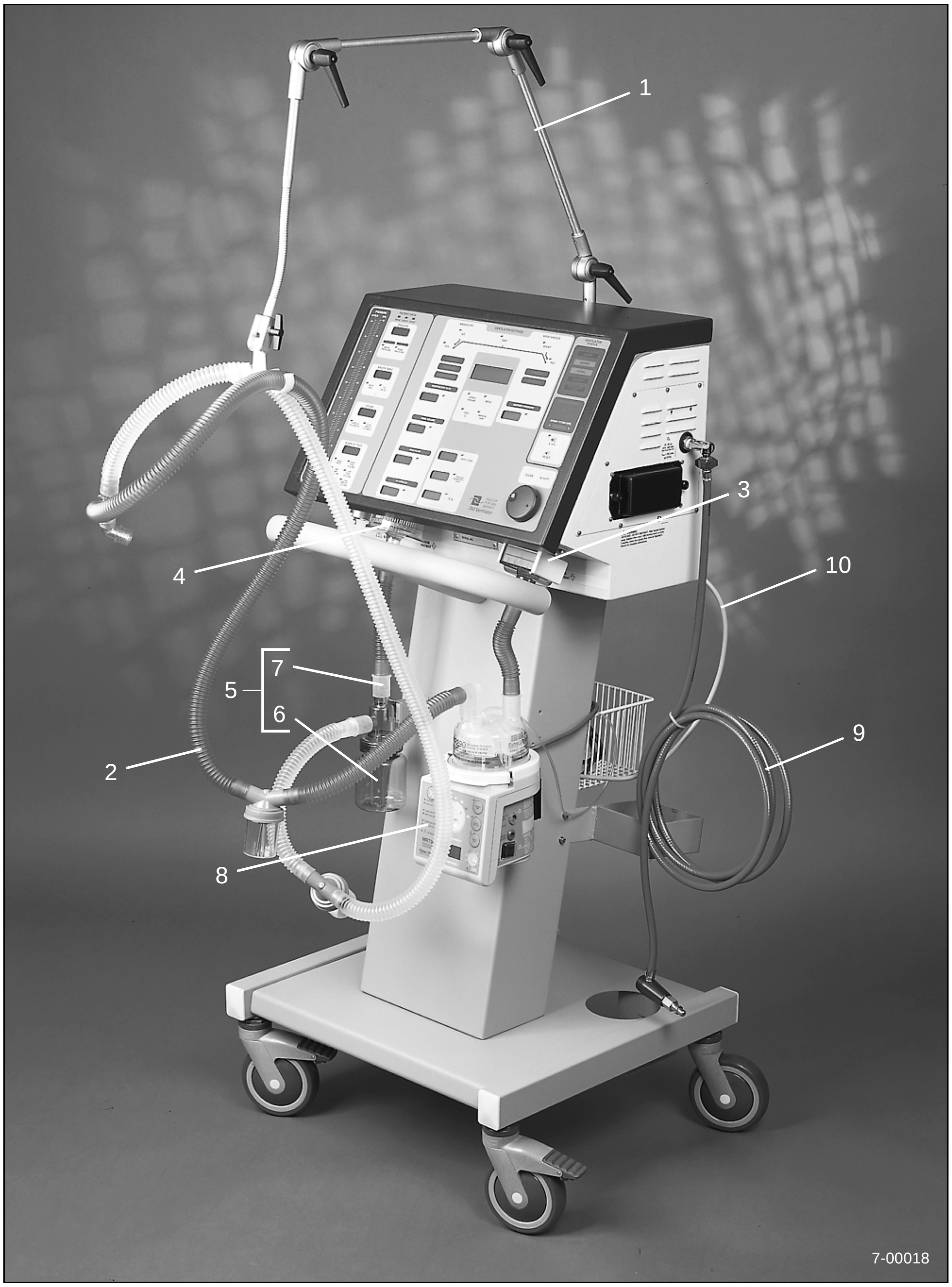
1
3
10
4
7
5
6
9
2
8
7-00018

Figure 9-1. ***700 Series Ventilator System***

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9.3 Oxygen hose assemblies

Oxygen hose assemblies parts list

Item no. (Figure 9-2)	Part no.	Quantity	Description
1	4-001474-00	1	Hose assembly, oxygen, DISS female x DISS female (for USA and Japan)
2	G-061268-00	1	Hose assembly, oxygen, DISS female x DISS male (for Canada) (not shown)
3	G-061191-00	1	Hose assembly, oxygen, Air Liquide (for France)
4	G-061197-00	1	Hose assembly, oxygen, for Australia (not shown)
5	G-061200-00	1	Hose assembly, oxygen, NIST (for United Kingdom)
6	5-029059-00	1	Hose assembly, oxygen, Dräger

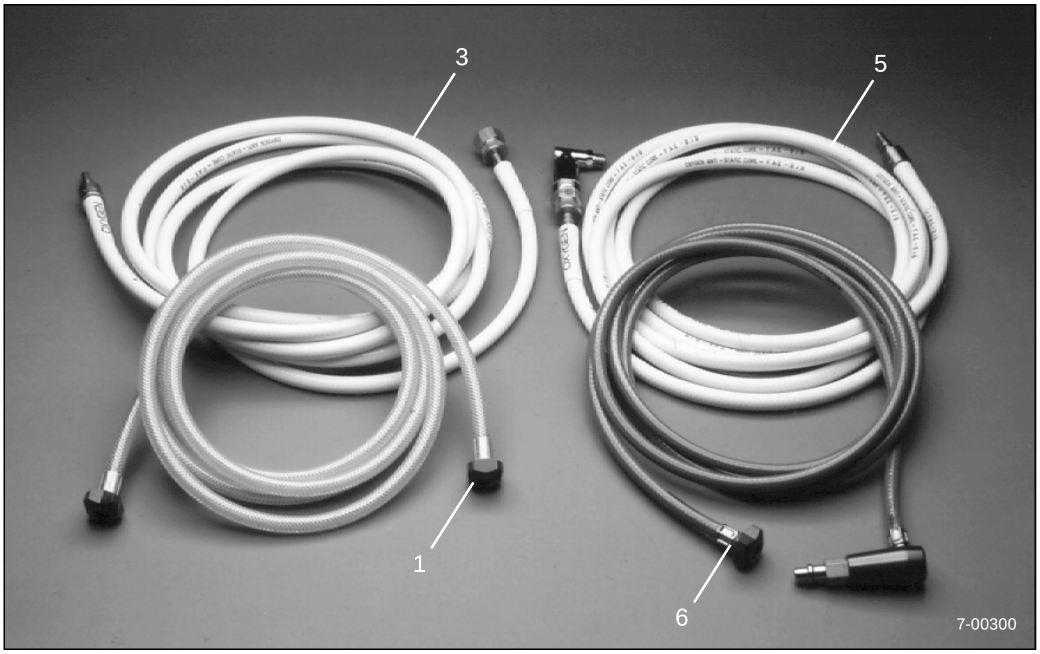


Figure 9-2. Oxygen hose assemblies

9.4 Flex arm assembly

Flex arm assembly parts list

Item no. (Figure 9-3)	Part no.	Quantity	Description
--	4-032006-00	--	Flex arm assembly

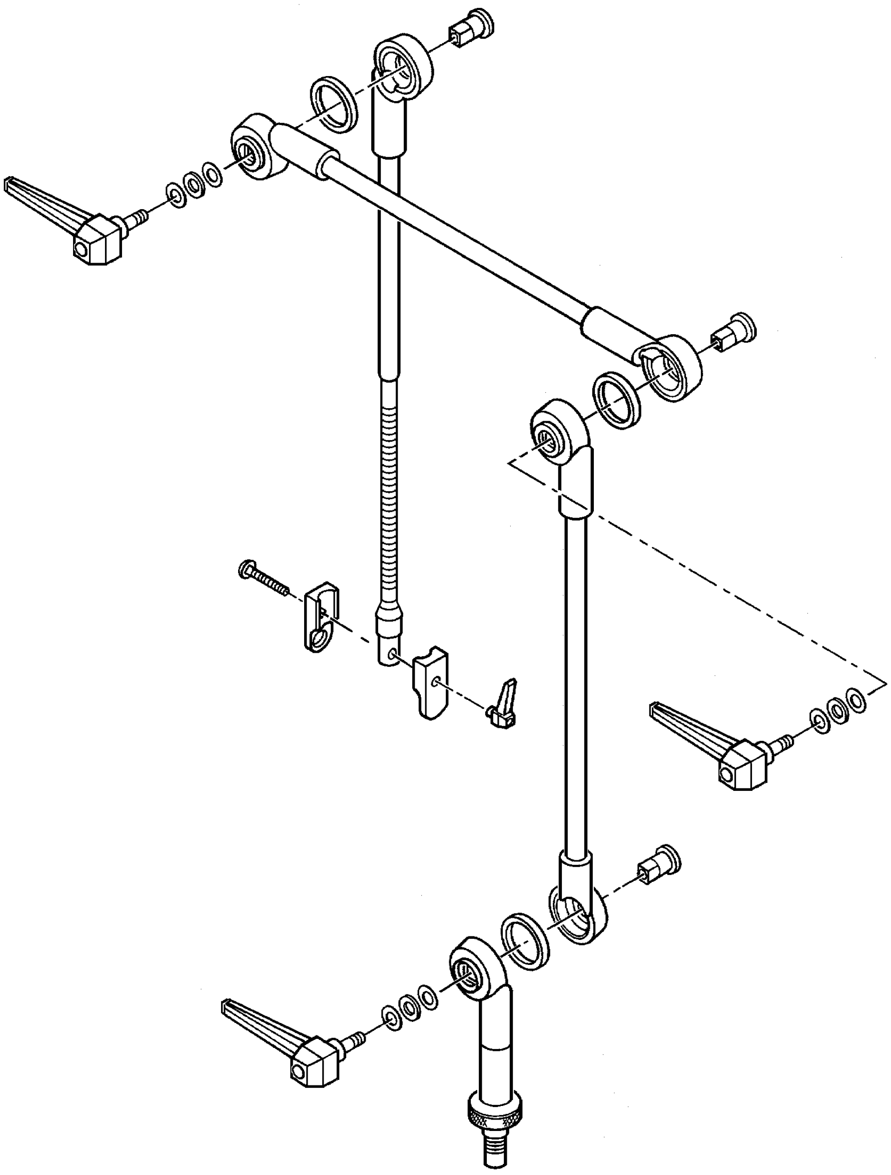
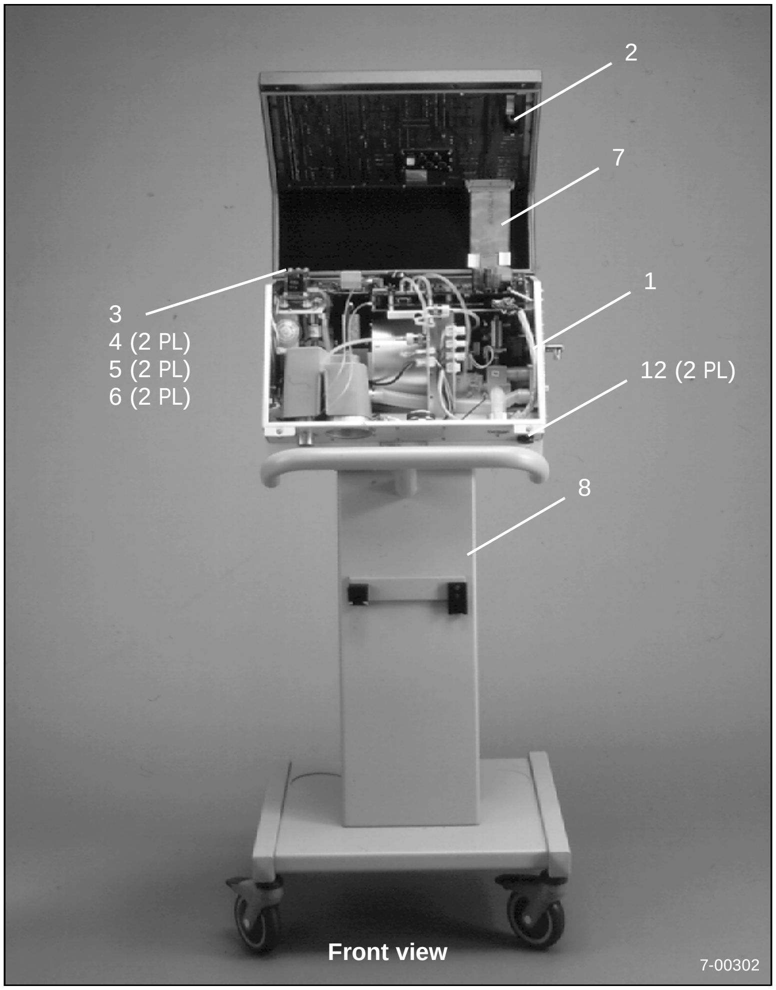


Figure 9-3. Flex arm assembly

9.5 Ventilator major assemblies

Ventilator major assemblies parts list

Item no. (Figure 9-4)	Part no.	Quantity	Description
1	--	1	Ventilator head assembly (See Section 9.9 for parts breakdown.)
2	--	1	User interface (UI) assembly (See Section 9.8 for parts breakdown.)
3	G-060514-00	1	Wire, ground, UI
4	G-060991-00	2	Nut, HEX, M5 (Attaches ground wire)
5	G-061030-00	2	Washer, IN LK, M5 (Attaches ground wire)
6	G-060999-00	2	Washer, flat, M5 (Attaches ground wire)
7	G-060100-00	1	Cable assembly, UI/ventilator head
8	--	1	Cart assembly (See Section 9.6 for parts breakdowns.)
9	--	2	• Screw, SOC, M6 x 16 (Attaches ventilator to cart) (not shown)
10	G-061649-00	2	• Washer, flat, M6 (Attaches ventilator to cart) (not shown)
11	--	2	• Washer, EX LK, M6 (Attaches ventilator to cart) (not shown)
12	G-062375-00	1	Latch retaining bracket kit
	--	2	• Latch lock bracket
	G-060979-00	2	• Screw, SOC, M4 x 12 (Secures bottom of lid)
13	G-061140-00	1	Battery kit, external
14	--	1	• Battery pack, external
15	G-061556-00		• • Fuse, 15 A, 32 V, blade (external battery) (not shown)
16	G-061176-00	1	• Cover, external battery
17	G-061279-00	1	Mounting kit, shelf, for use with Fisher & Paykel humidifiers (not shown) (See Section 9.7.)
18	G-062195-00	1	External battery charger adapter (not shown)


2
7
1
3
4 (2 PL)
5 (2 PL)
6 (2 PL)
12 (2 PL)
8
Front view
7-00302

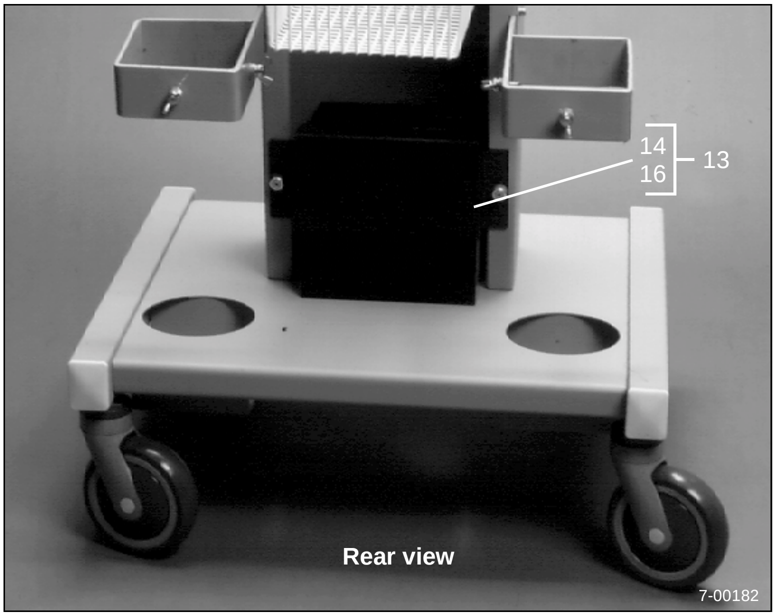

14
16
13
Rear view
7-00182

Figure 9-4. Ventilator major assemblies

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9.6 Cart assembly

Cart assembly parts list

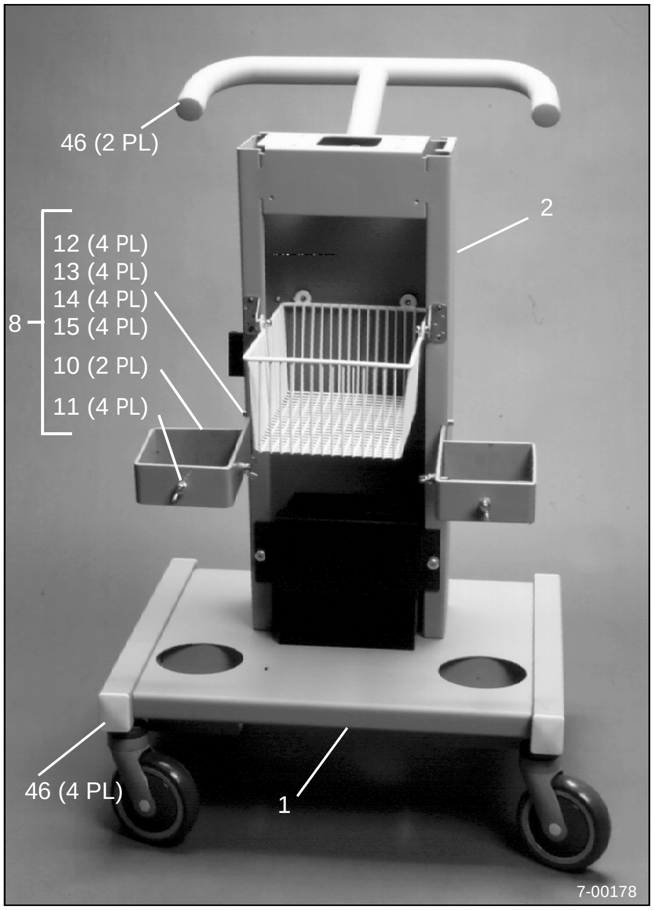
Item no. (Figure 9-5)	Part no.	Quantity	Description
--	G-061581-00	--	Cart assembly, for use with Fisher & Paykel humidifiers (Includes items 1- 36)
	G-061582-00	--	Cart assembly, for use with Hudson RCI ConchaTherm 3 humidifier (Includes items 1- 30 and 37- 45)
1	G-062215-00	1	• Base assembly
2	G-062216-00	1	• Column assembly
3	--	6	• Screw, SOC, M6 x 16 (Attaches column to base)
4	G-061649-00	6	• Washer, flat, M6 (Attaches column to base)
5	--	6	• Washer, EX LK, M6 (Attaches column to base)
6	--	2	• Cover, oxygen cylinder (not shown)
7	--	8	• Nut, HEX, with washer, EX LK, M4 (Attaches cylinder cover or cylinder support to cart)
8	G-061280-00	1	• Mounting kit, oxygen cylinder
9	--	2	• • Support, oxygen cylinder (lower)
10	--	2	• • Bracket, oxygen cylinder (upper)
11	--	4	• • Screw, wing, M10 (Attaches cylinder bracket to cylinder)
12	--	4	• • Screw, SOC, M6 x 16 (Attaches cylinder bracket to cart)
13	G-061649-00	4	• • Washer, flat, M6 (Attaches cylinder bracket to cart)
14	--	4	• • Washer, EX LK, M6 (Attaches cylinder bracket to cart)
15	--	4	• • Nut, HEX, with washer, EX LK, M6 (Attaches cylinder bracket to cart)
16	G-061124-00	1	• Mounting kit, collector vial, cart-mount
17		1	• • Bracket, collector vial support
18	G-060978-00	2	• • Screw, SOC, M4 x 8 (Attaches collector vial support bracket to cart)
19	G-061028-00	2	• • Washer, flat, M4 (Attaches collector vial support bracket to cart)
20	G-060996-00	2	• • Washer, SR, M4 (Attaches collector vial support bracket to cart)
21	--	1	• • Allen key, 3-mm (not shown)
22	G-061205-00	1	• Basket
23	--	2	• Bracket, ball (Attaches basket to cart) (Part of hardware kit, item 47)

Cart assembly parts list (continued)

Item no. (Figure 9-5)	Part no.	Quantity	Description
24	--	4	• Screw, PAN, M4 x 12, Phillips (Attaches ball bracket to cart) (Part of hardware kit, item 47)
25	G-061028-00	4	• Washer, flat, M4 (Attaches ball bracket to cart) (Part of hardware kit, item 47)
26	G-060994-00	4	• Washer, IN LK, M4 (Attaches ball bracket to cart) (Part of hardware kit, item 47)
	G-061849-00	--	Ventilator attachment kit (attaches ventilator to cart, includes items 27-29)
27	--	2	• Screw, SOC, M6 x 16 (Attaches ventilator to cart)
28	G-061649-00	2	• Washer, flat, M6 (Attaches ventilator to cart)
29	--	2	• Washer, EX LK, M6 (Attaches ventilator to cart)
30	--	1	• Allen key, 5-mm (not shown)
31	G-061227-00	--	• Mounting kit, Fisher & Paykel humidifier, cart (Mounts humidifier to cart)
32	--	1	• • Support bracket, Fisher & Paykel humidifier
33	G-061202-00	2	• • Screw, SOC, M5 x 12 (Attaches Fisher & Paykel humidifier support bracket to cart)
34	G-060999-00	2	• • Washer, flat, M5 (Attaches humidifier support bracket to cart)
35	G-060997-00	2	• • Washer, SR, M5 (Attaches humidifier support bracket to cart)
36	--	1	• Allen key, 4-mm (not shown)
37	G-061228-00	--	• Mounting kit, Hudson RCI ConchaTherm 3 humidifier, cart (Mounts humidifier to cart)
38	G-061603-00	1	• • Bracket assembly, slide, Hudson RCI ConchaTherm 3 humidifier
39	G-061646-00	1	• • Bracket, cart interface, Hudson RCI ConchaTherm 3 humidifier, cart-mount
40	G-061647-00	4	• • Screw, FH, M5 x 25, POZIDRIV (Attaches support bracket to cart interface bracket)
41	G-060999-00	4	• • Washer, flat, M5 (Attaches Hudson support bracket to cart interface bracket)
42	G-060991-00	4	• • Nut, HEX, M5 (Attaches Hudson support bracket to cart interface bracket)
43	G-061648-00	2	• • Screw, PAN, M6 x 20, POZIDRIV (Attaches Hudson humidifier bracket assembly to cart)
44	G-061649-00	2	• • Washer, flat, M6 (Attaches Hudson humidifier bracket assembly to cart)
45	G-061017-00	2	• • Washer, SR, M6 (Attaches Hudson humidifier bracket assembly to cart)

Cart assembly parts list (continued)

Item no. (Figure 9-5)	Part no.	Quantity	Description
46	G-062019-00	1	Bumpers, cart (quantity 4 for cart base, 2 for cart handles) (not shown)
47	G-062213-00	1	Hardware kit, cart (not shown)
48	G-062187-00	2	Caster, back, without brake
49	G-062186-00	2	Caster, front, with brake


46 (2 PL)
2
12 (4 PL)
13 (4 PL)
14 (4 PL)
15 (4 PL)
8
10 (2 PL)
11 (4 PL)
46 (4 PL)
1
7-00178

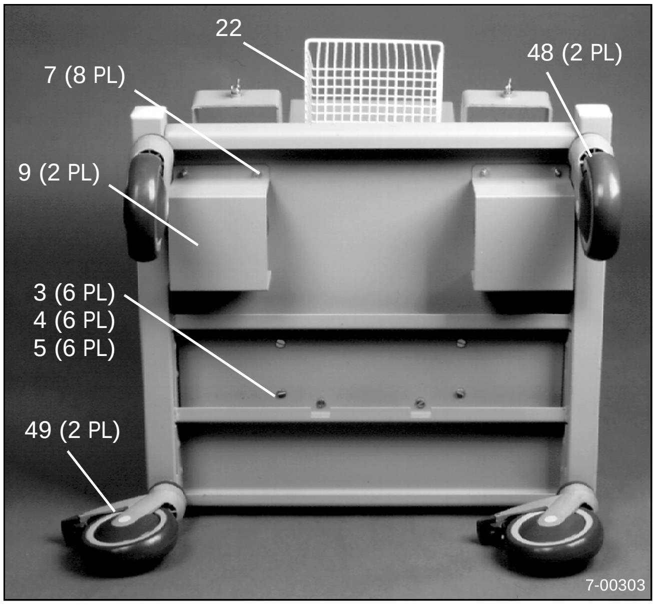
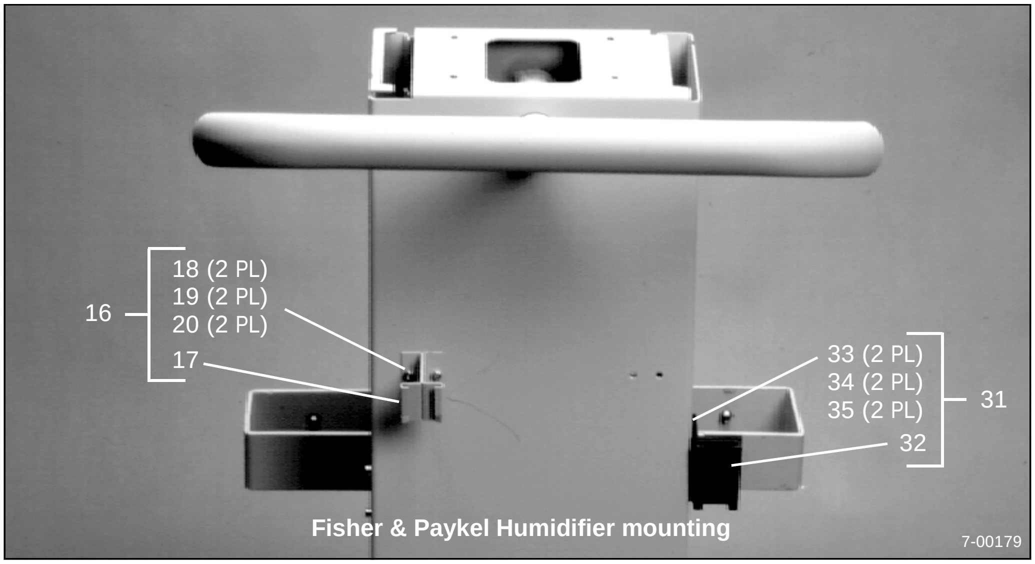
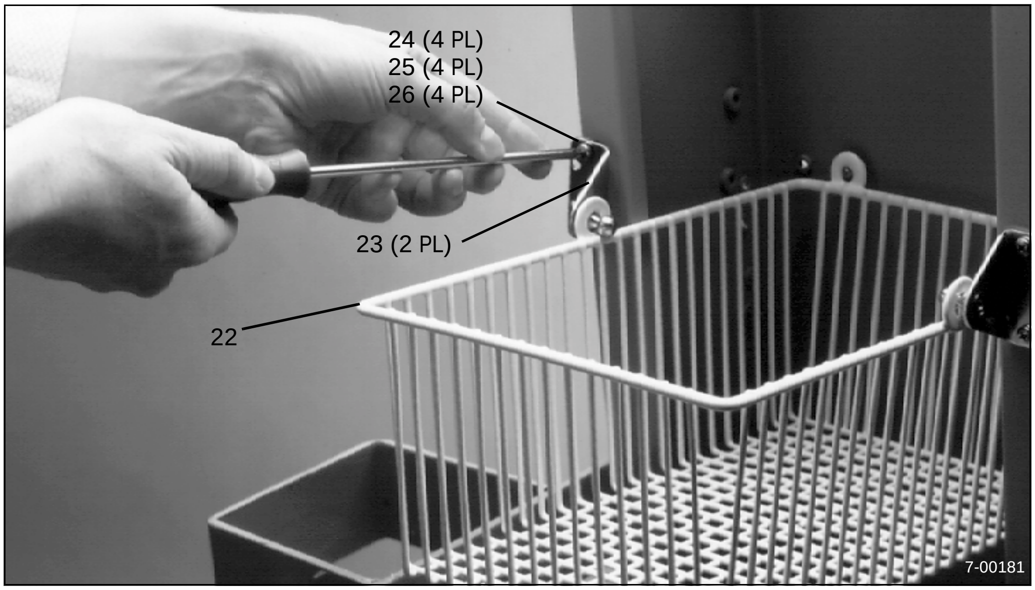

22
48 (2 PL)
7 (8 PL)
9 (2 PL)
3 (6 PL)
4 (6 PL)
5 (6 PL)
49 (2 PL)
7-00303

Figure 9-5. Cart assembly (Sheet 1 of 3)


16
18 (2 PL)
19 (2 PL)
20 (2 PL)
17
33 (2 PL)
34 (2 PL)
35 (2 PL)
32
31
Fisher & Paykel Humidifier mounting
7-00179


24 (4 PL)
25 (4 PL)
26 (4 PL)
23 (2 PL)
22
7-00181

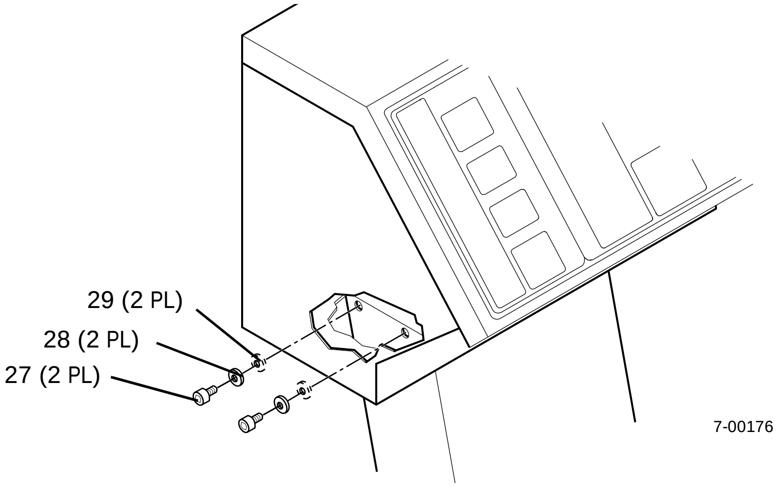
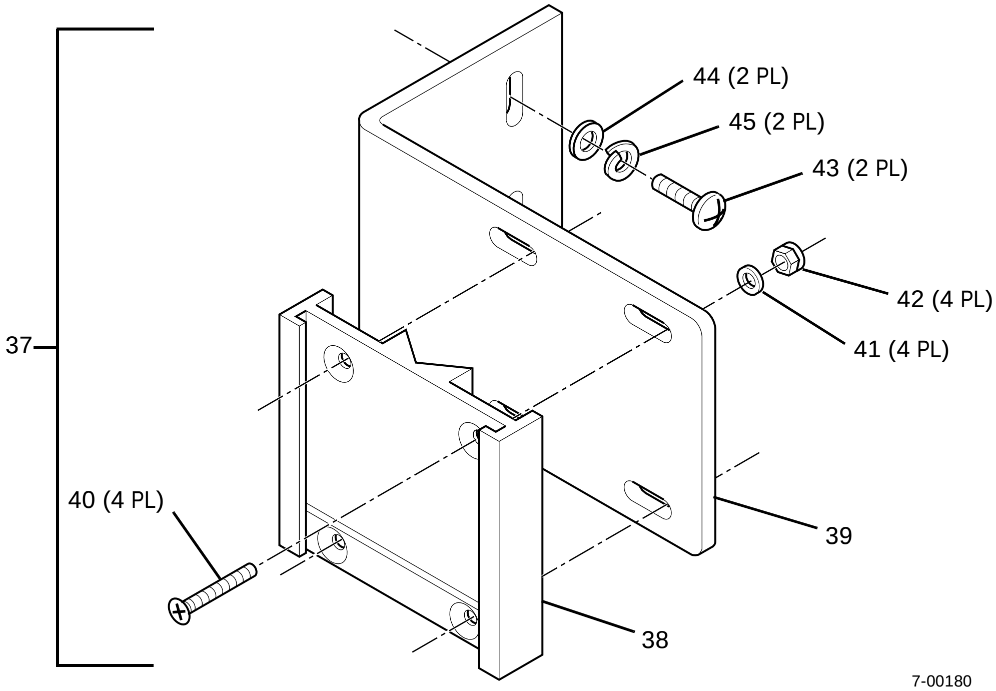

29 (2 PL)
28 (2 PL)
27 (2 PL)
7-00176

Figure 9-5. Cart assembly (Sheet 2 of 3)


44 (2 PL)
45 (2 PL)
43 (2 PL)
42 (4 PL)
41 (4 PL)
37
40 (4 PL)
39
38
7-00180

Hudson RCI ConchaTherm 3 humidifier mounting

Figure 9-5. Cart assembly (Sheet 3 of 3)

9.7 Shelf mounting kit

Shelf mounting kit parts list

Item no. (Figure 9-6)	Part no.	Quantity	Description
--	G-061279-00	--	Mounting kit, shelf, for use with Fisher & Paykel humidifiers (Includes items 1 - 22)
	G-061601-00	--	Mounting kit, shelf, for use with Hudson RCI ConchaTherm 3 humidifier (Includes items 1 - 19 and 23 - 24)
1	G-061151-00	1	• Bracket, shelf mounting
2	G-061154-00	1	• Plate, shelf mounting
3	--	3	• Screw, SOC, M5 x 10 (Attaches plate to bracket)
4	G-060999-00	3	• Washer, flat, M5 (Attaches plate to bracket)
5	G-060997-00	3	• Washer, SR, M5 (Attaches plate to bracket)
6	G-061289-00	1	• Collector vial bracket, shelf-mount
7	G-061477-00	2	• Screw, SOC, M4 x 10 (Attaches collector vial bracket to plate)
8	G-061028-00	2	• Washer, flat, M4 (Attaches collector vial bracket to plate)
9	G-060996-00	2	• Washer, SR, M4 (Attaches collector vial bracket to plate)
10	G-060980-00	1	• Screw, SOC, M5 x 8 (Attaches ventilator to shelf mount) (not shown)
11	G-060999-00	1	• Washer, flat, M5 (Attaches ventilator to shelf mount) (not shown)
12	G-060997-00	1	• Washer, SR, M5 (Attaches ventilator to shelf mount) (not shown)
13	--	4	• Screw, SOC, M6 x 30 (Attaches assembled ventilator/mount to shelf) (not shown)
14	G-061649-00	8	• Washer, flat, M6 (Attaches assembled ventilator/mount to shelf) (not shown)
15	G-061017-00	4	• Washer, SR, M6 (Attaches assembled ventilator/mount to shelf) (not shown)
16	--	4	• Nut, HEX, M6 (Attaches assembled ventilator/mount to shelf) (not shown)
17	--	1	• Allen key, 3-mm (not shown)
18	--	1	• Allen key, 4-mm (not shown)
19	--	1	• Allen key, 5-mm (not shown)
20	G-061602-00	--	• Mounting kit, Fisher & Paykel humidifier, shelf (not shown)

Shelf mounting kit parts list (continued)

Item no. (Figure 9-6)	Part no.	Quantity	Description
21	--	1	• • Support bracket, Fisher & Paykel humidifier (not shown)
22	G-061476-00	2	• • Screw, FH, M5 x 10 (Attaches Fisher & Paykel humidifier support bracket to plate) (not shown)
23	G-061603-00	1	• • Bracket assembly, slide, Hudson RCI ConchaTherm 3 humidifier
24	G-061650-00	4	• Screw, FH, M5 x 20, POZIDRIV (Attaches Hudson RCI ConchaTherm 3 humidifier support bracket to plate)

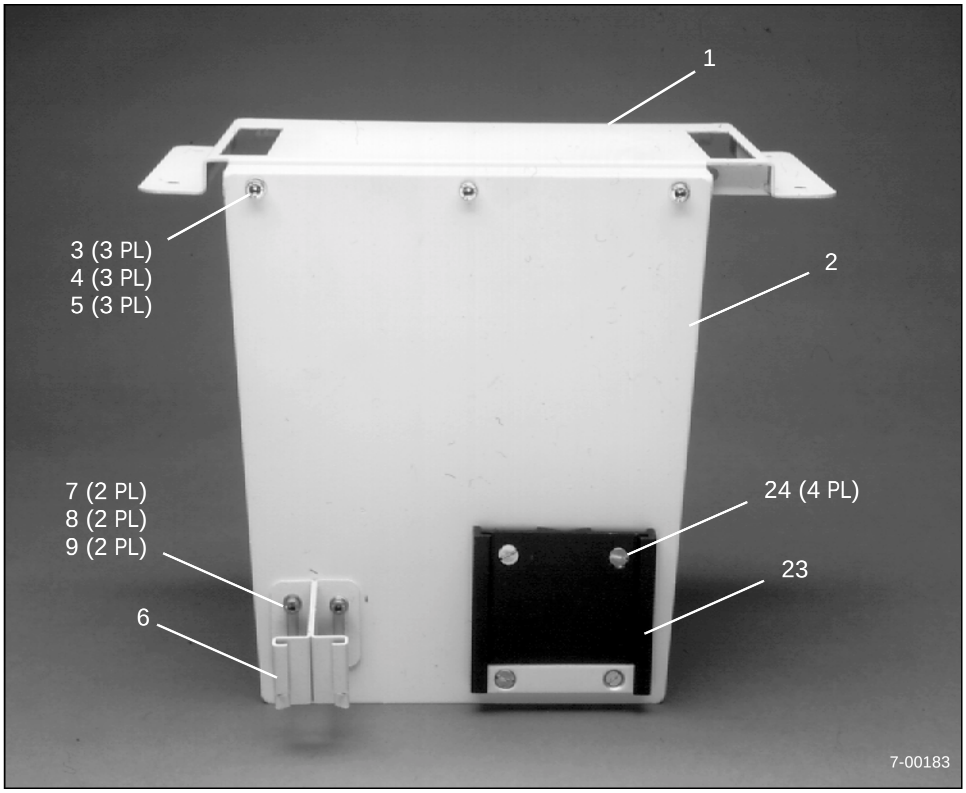


Figure 9-6. Shelf mounting kit

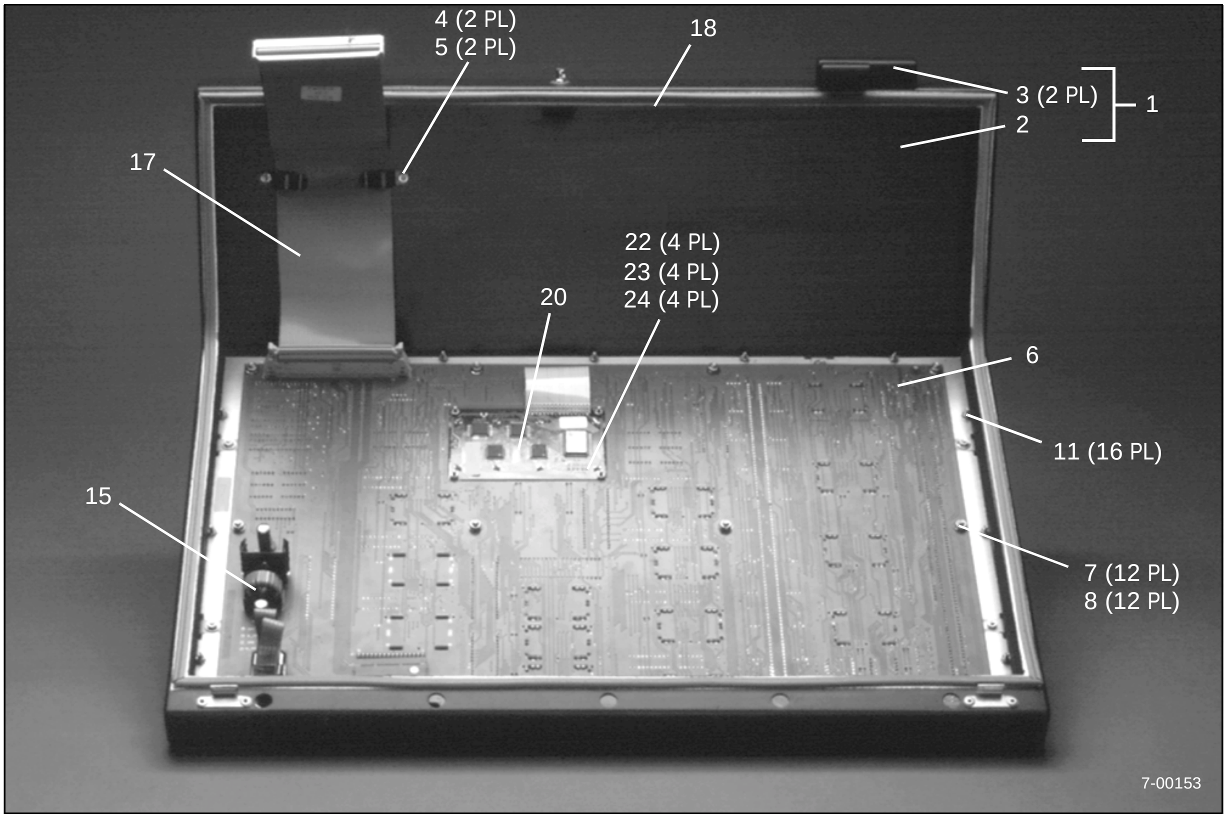
9.8 User interface (UI) assembly

User interface (UI) assembly parts list

Item no. (Figure 9-7)	Part no.	Quantity	Description
--	--	--	User interface (UI) assembly
1	G-061427-00	1	• Lid assembly
2	--	1	• • Lid
3	--	2	• • Hinge
4	G-061097-00	2	• Clip, tension
5	G-061055-00	2	• Nut, HEX, with washer, EX LK, M3 (Attaches tension clip)
6	G-061130-00	1	• PCB, *740* UI display
	G-062227-00	1	• PCB, *760* UI display
7	G-060990-00	12	• Nut, HEX, M4 (Attaches keyboard to PCB)
8	G-060994-00	12	• Washer, IN LK, M4 (Attaches keyboard to PCB)
9	G-060905-00	12	• Spacer, M4, nylon, UI subpanel (Attaches keyboard to PCB)
10	G-061141-00	1	• Keyboard, *740* UI, English (not shown)
	G-061148-00	1	• Keyboard, *740* UI, French (not shown)
	G-061163-00	1	• Keyboard, *740* UI, German (not shown)
	G-061164-00	1	• Keyboard, *740* UI, Italian (not shown)
	G-061497-00	1	• Keyboard, *740* UI, Japanese (not shown)
	G-061165-00	1	• Keyboard, *740* UI, Polish (not shown)
	G-061145-00	1	• Keyboard, *740* UI, Portuguese (not shown)
	G-061146-00	1	• Keyboard, *740* UI, Russian (not shown)
	G-061147-00	1	• Keyboard, *740* UI, Spanish (not shown)
	G-062218-00	1	• Keyboard, *760* UI, English (not shown)
	G-062219-00	1	• Keyboard, *760* UI, French (not shown)
	G-062220-00	1	• Keyboard, *760* UI, German (not shown)
	G-062221-00	1	• Keyboard, *760* UI, Italian (not shown)
	G-062222-00	1	• Keyboard, *760* UI, Japanese (not shown)
	G-062223-00	1	• Keyboard, *760* UI, Polish (not shown)
	G-062224-00	1	• Keyboard, *760* UI, Portuguese (not shown)
	G-062225-00	1	• Keyboard, *760* UI, Russian (not shown)
	G-062226-00	1	• Keyboard, *760* UI, Spanish (not shown)
11	G-061055-00	16	• Nut, HEX, with washer, EX LK, M3 (Attaches UI to lid)
12	4-073005-00	1	• Knob (not shown)
13	--	1	• • Washer, IN LK (Attaches rotary encoder) (not shown)
14	--	1	• • Nut, HEX (Attaches rotary encoder) (not shown)
15	G-060771-00	1	• Rotary encoder, UI

User interface (UI) assembly parts list (continued)

Item no. (Figure 9-7)	Part no.	Quantity	Description
16	G-060906-00	1	• Spacer, nylon, UI encoder (Attaches rotary encoder) (not shown)
17	G-060100-00	1	• Cable assembly, UI/ventilator head
18	G-060466-00	1	• Gasket, main (outer), 1900 mm
19	G-060128-00	1	• Seal, UI
20	G-061430-00	1	• LCD panel, European
	G-061142-00	1	• LCD panel, English/Japanese
	G-061793-00	1	• LCD panel, Russian/Polish
21	G-060907-00	4	• Spacer, M2.5, nylon, UI message window (Attaches LCD panel) (not shown)
22	G-060992-00	4	• Washer, IN LK, M2.5 (Attaches LCD panel)
23	G-060988-00	4	• Nut, HEX, M2.5 (Attaches LCD panel)
24	G-061719-00	4	• Washer, fiber (Attaches LCD panel)


4 (2 PL)
5 (2 PL)
18
3 (2 PL)
2
1
17
22 (4 PL)
23 (4 PL)
24 (4 PL)
20
6
11 (16 PL)
15
7 (12 PL)
8 (12 PL)
7-00153

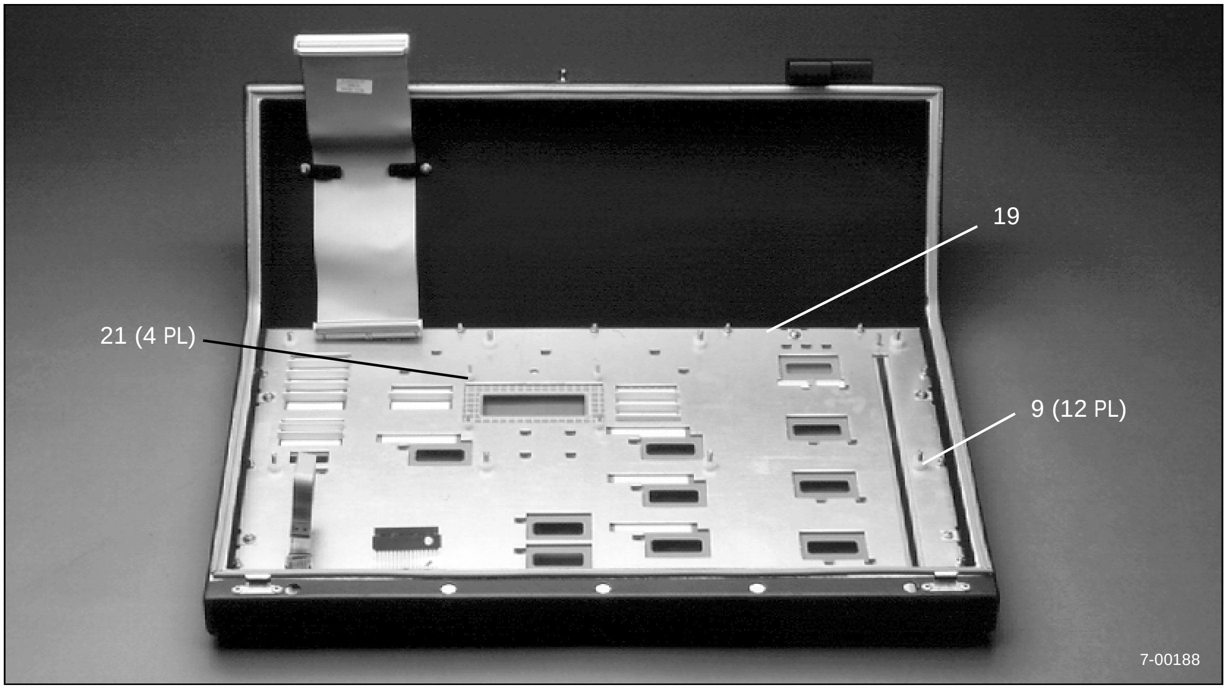

19
21 (4 PL)
9 (12 PL)
7-00188

Figure 9-7. User interface (UI) assembly

9.9 Ventilator head assembly

Ventilator head assembly parts list

Item no. (Figure 9-8)	Part no.	Quantity	Description
--	--	--	Ventilator head assembly
1	G-061132-00	1	• Cabinet assembly **(Also order a label kit (item 20).)**
2	--	1	• • Enclosure assembly
3	G-060450-00	1	• • Plate, options panel
4	G-062303-00	1	• • Plate, inspiratory access panel, English
	G-062304-00		• • Plate, inspiratory access panel, French
	G-062305-00		• • Plate, inspiratory access panel, German
	G-062306-00		• • Plate, inspiratory access panel, Italian
	G-062307-00		• • Plate, inspiratory access panel, Spanish
	G-062308-00		• • Plate, inspiratory access panel, Portuguese
	G-062309-00		• • Plate, inspiratory access panel, Polish
	G-062310-00		• • Plate, inspiratory access panel, Russian
	G-062311-00		• • Plate, inspiratory access panel, Japanese
	G-062312-00		• • Plate, inspiratory access panel, Dutch
5	G-060448-00	1	• • Plate, battery compartment access
6	G-060473-00	1	• • Grommet, regulator
7	G-061182-00	2	• • Rivet (not shown) (Attaches serial number plate)
8	G-061122-00	7	• Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches options panel plate)
9	--	--	• Not used
10	--	--	• Not used
11	G-061122-00	9	• Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches inspiratory access panel plate)
12	--	--	• Not used
13	--	--	• Not used
14	G-061094-00	4	• Screw, PAN, M3 x 12, POZIDRIV, with washers (Attaches battery compartment access plate)
15	--	--	• Not used
16	--	--	• Not used
17	--	2	• Shoulder bolt, M4 (Attaches oxygen regulator bracket to inspiration access panel plate) (order grommet and shoulder bolt kit P/N G-062297-00)

Ventilator head assembly parts list (continued)

Item no. (Figure 9-8)	Part no.	Quantity	Description
18	--	2	• Grommet (for use with shoulder bolt, item 17) (order grommet and shoulder bolt kit P/N G-062297-00 or grommet kit P/N G-062301-00 for grommets only)
19	G-062292-00	1	• Grounding strap kit, inspiration access panel (kit includes grounding strap, installation instructions, and hardware to attach strap between oxygen regulator and inside of panel) (not shown)
20	G-061388-00	1	• Label kit, English, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061390-00	1	• Label kit, French, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061389-00	1	• Label kit, German, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061391-00	1	• Label kit, Italian, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061395-00	1	• Label kit, Japanese, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061394-00	1	• Label kit, Polish, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061393-00	1	• Label kit, Portuguese, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061396-00	1	• Label kit, Russian, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-061392-00	1	• Label kit, Spanish, *740* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062172-00	1	• Label kit, Dutch, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062164-00	1	• Label kit, English, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062165-00	1	• Label kit, French, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062160-00	1	• Label kit, German, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062167-00	1	• Label kit, Italian, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062171-00	1	• Label kit, Japanese, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062169-00	1	• Label kit, Polish, *760* Ventilator (See Section 9.11 for contents.) (not shown)

Ventilator head assembly parts list (continued)

Item no. (Figure 9-8)	Part no.	Quantity	Description
	G-062189-00	1	• Label kit, Portuguese, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062170-00	1	• Label kit, Russian, *760* Ventilator (See Section 9.11 for contents.) (not shown)
	G-062168-00	1	• Label kit, Spanish, *760* Ventilator (See Section 9.11 for contents.) (not shown)
21	G-060121-00	1	• Mounting block, flex arm
22	G-061091-00	4	• Screw, PAN, M5 x 16, POZIDRIV (Attaches mounting block)
23	G-060997-00	4	• Washer, SR, M5 (Attaches mounting block)
24	4-019063-00	1	• Fitting, oxygen, DISS male
25	--	1	• Filter assembly, air intake
26	G-062026-00	1	• • Manifold assembly, air intake (replaces previous air intake manifold P/N G-060217-00)
27	G-060218-00	1	• • Cover, air intake
28	G-061262-00	1	• • Filter, air intake (package of 6)
29	G-061122-00	4	• • Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches air intake filter assembly)
30	G-062025-00	1	• • Check valve, air intake (blue housing)
31	G-062024-00	1	• • Check valve, pressure relief (white housing)
32	G-060845-00	1	• Thermistor assembly, air flow
33	G-060976-00	2	• Screw, SOC, M3 x 8 (Attaches air flow thermistor assembly)
34	G-060995-00	2	• Washer, SR, M3 (Attaches air flow thermistor assembly)
35	--	--	• Inspiration manifold assembly (See Section 9.12 for parts breakdown.)
36	--	--	• Oxygen regulator assembly (See Section 9.13 for parts breakdown.)
37	--	--	• Exhalation assembly (See Section 9.14 for parts breakdown.)
38	G-060924-00	1	• Cable management bar, PCBs, speaker, and piezo alarm (See Section 9.15 for parts breakdown.)
39	--	--	• PEEP pump and reservoir (See Section 9.16 for parts breakdown.)
40	--	--	• Piston/cylinder and motor/encoder assembly (See Section 9.17 for parts breakdown.)

Ventilator head assembly parts list (continued)

Item no. (Figure 9-8)	Part no.	Quantity	Description
41	--	--	• Ventilator rear components (See Section 9.18 for parts breakdown.)
42	--	--	• Power assembly (See Section 9.19 for parts breakdown.)
43	--	--	• Tubing (See Section 9.21.)
44	G-060759-00	As needed	• Tape, PTFE (Used on threads of oxygen fitting) (not shown)
45	G-061093-00	1	• Caplug, DISS fitting (not shown)
46	--	1	• Plate, serial number (not shown)
47	G-060976-00	1	• Screw, SOC, M3 x 8 (Attaches cable tie that retains main ventilator head harness) (not shown)
48	G-060995-00	1	• Washer, SR, M3 (Attaches cable tie that retains main ventilator head harness) (not shown)
49	G-060998-00	1	• Washer, flat, M3 (Attaches cable tie that retains main ventilator head harness) (not shown)
50	G-061088-00	1	• Tie wrap, air intake (Attaches BBU PCB/controller PCB harness to upper righthand screw at rear of air intake housing) (not shown)
51	G-061572-00	1	• Switch, air intake filter
52	G-061622-00	2	• Screw, PAN, M3 x 14, POZIDRIV (Attaches air intake filter switch to manifold)
53	--	1	• Oxygen hose adapters (Used on all ventilators except those supplied with DISS female x female and Dräger hose assemblies) (See Section 9.10 for parts breakdowns.)(not shown)

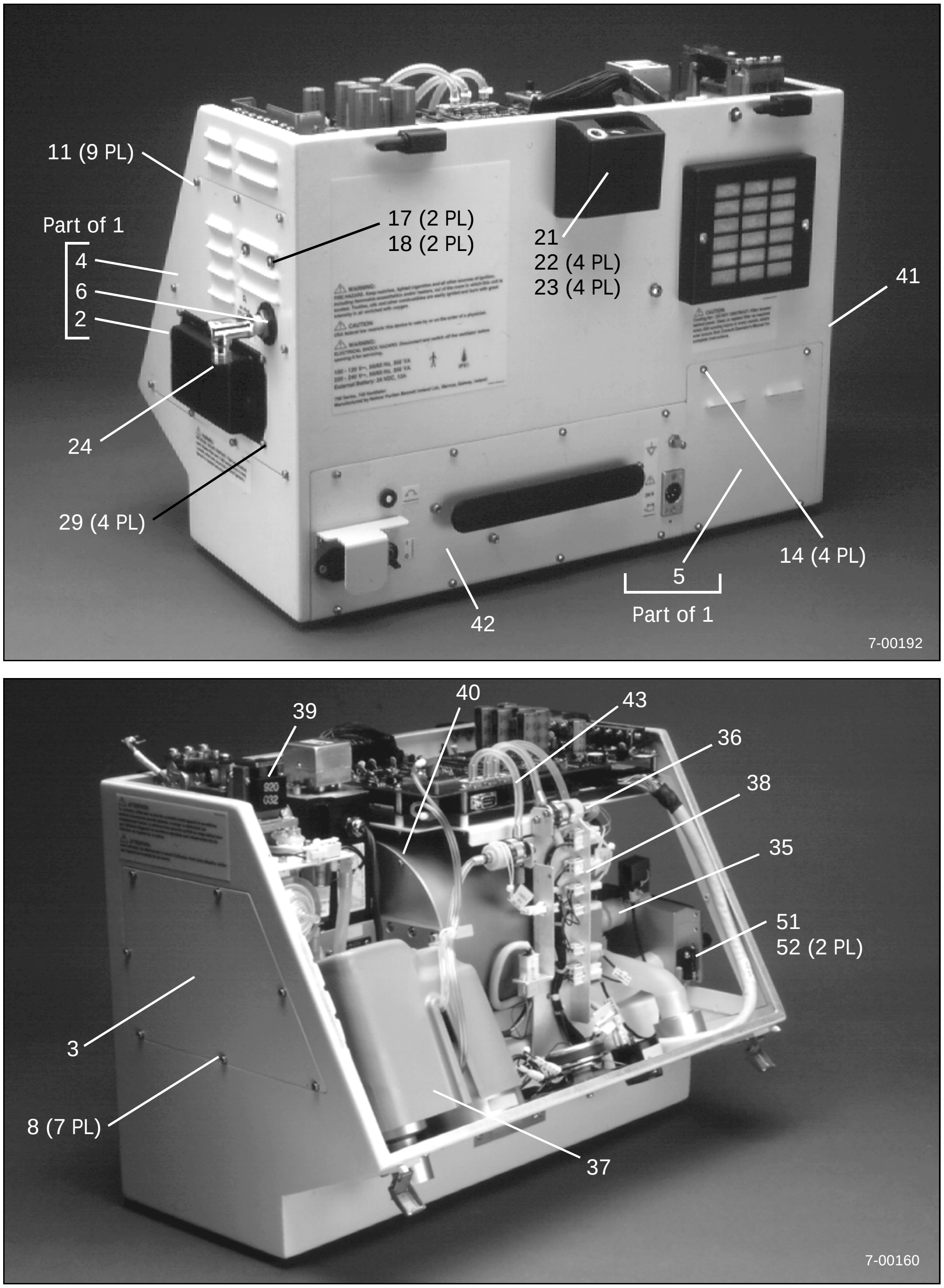
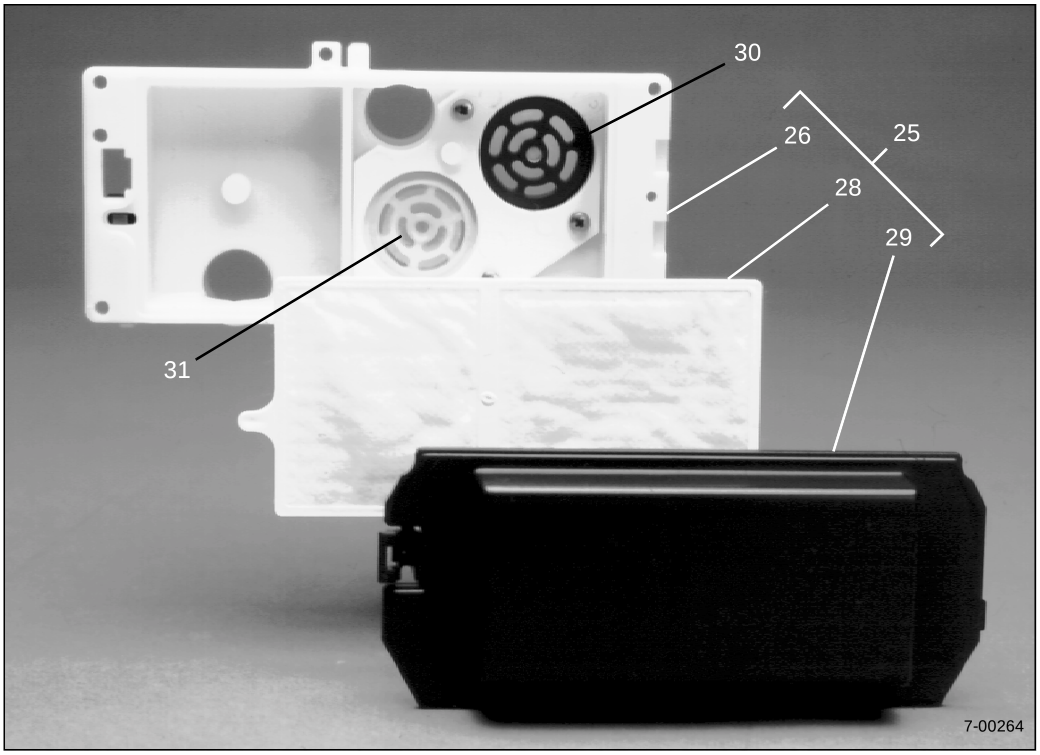

11 (9 PL)
Part of 1
4
6
2
17 (2 PL)
18 (2 PL)
21
22 (4 PL)
23 (4 PL)
41
24
29 (4 PL)
14 (4 PL)
5
Part of 1
42
7-00192
39
40
43
36
38
35
51
52 (2 PL)
3
8 (7 PL)
37
7-00160

Figure 9-8. Ventilator head assembly (Sheet 1 of 2)


30
26
25
28
29
31
7-00264

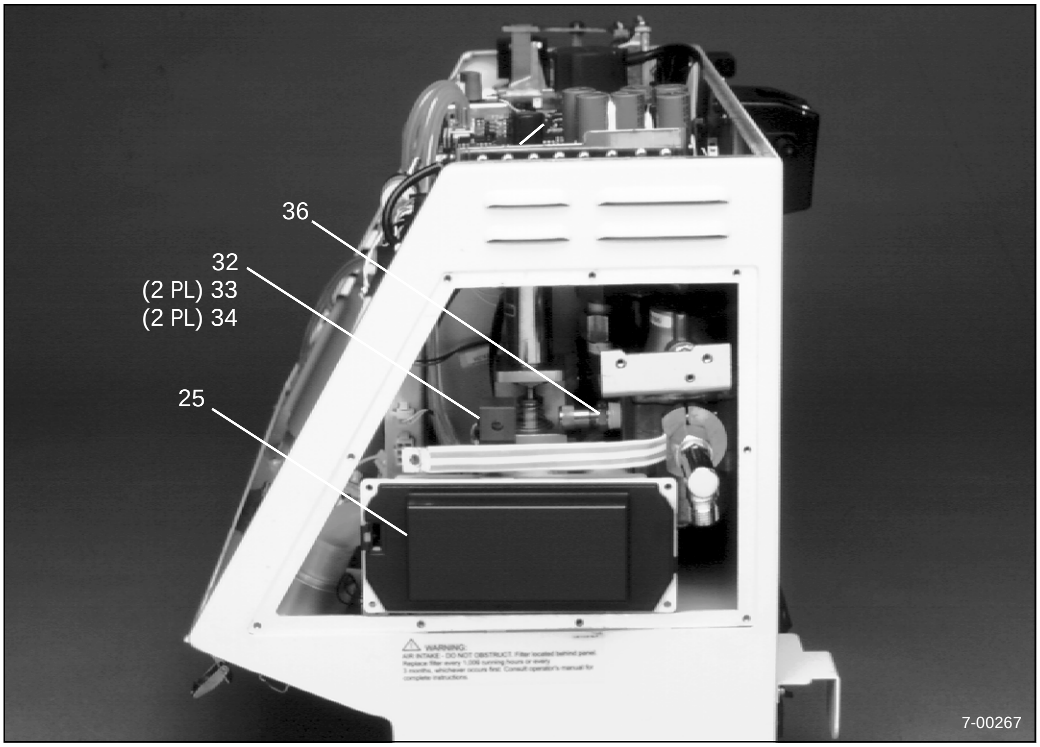

36
32
(2 PL) 33
(2 PL) 34
25
WARNING:
AIR INTAKE - DO NOT OBSTRUCT. Filter located behind panel.
7-00267

Figure 9-8. Ventilator head assembly (Sheet 2 of 2)

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9.10 Oxygen hose adapters

Oxygen hose adapters parts list

Item no. (Figure 9-9)	Part no.	Quantity	Description
1	G-061267-00	1	Adapter, oxygen hose, DISS male to DISS male (for Canada)
2	G-061192-00	1	Adapter, oxygen hose, DISS male to Air Liquide (for France)
3	G-061193-00	1	Connector with O-ring, oxygen hose, Air Liquide (for France)
4	G-061194-00	1	• O-ring, oxygen hose, Air Liquide (for France)
5	--	1	• Connector, oxygen hose, Air Liquide (for France)
6	G-061177-00	1	Adapter, oxygen hose, DISS male to 1/4 NPT (for United Kingdom/Australia)
7	G-061199-00	1	Connector, oxygen hose, 1/4 NPT to NIST (for United Kingdom)
8	G-061195-00	1	Adapter, oxygen hose, 1/4 NPT to Australian type (not shown)
9	G-061196-00	1	Collar, oxygen hose, Australian type (not shown)
10	G-060759-00	As needed	Tape, PTFE (Used on threads of oxygen adapters as shown. For Australian type adapter assembly, used on threads of DISS fitting and 1/4 NPT adapter.)
11	G-062194-00	1	Hose assembly, connector, Swiss (not shown)

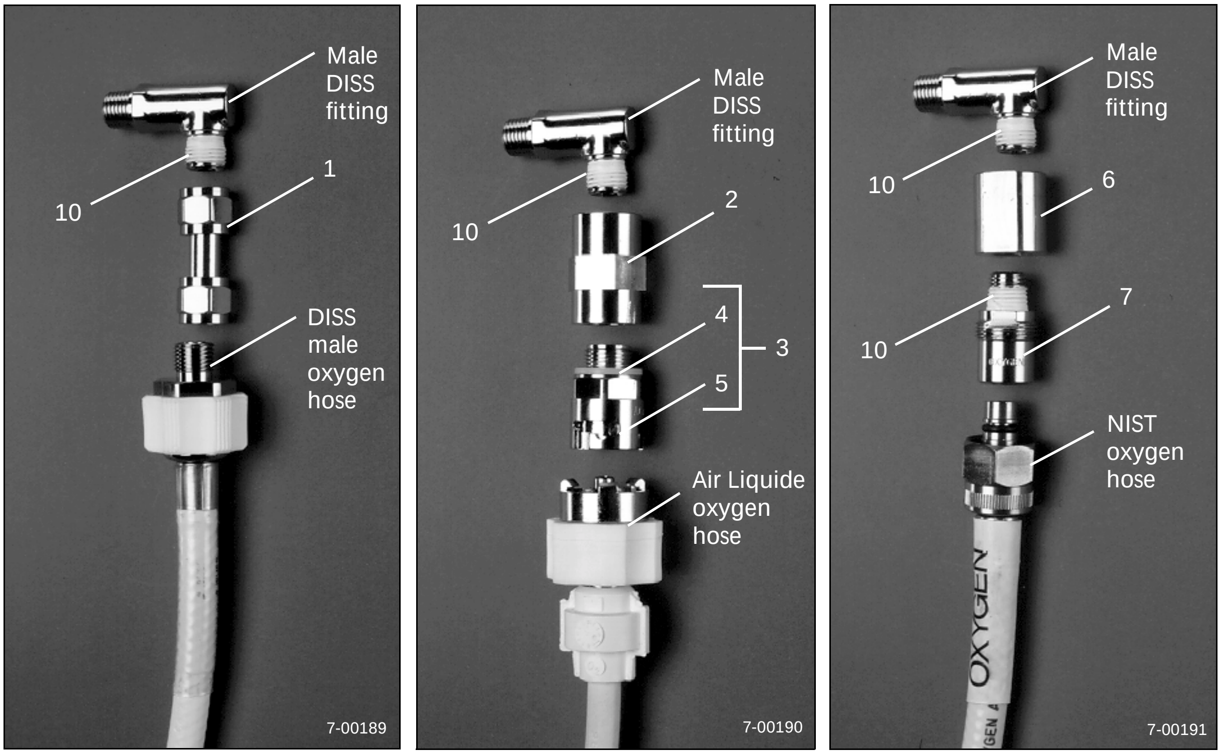
Male
DISS
fitting
1
10
DISS
male
oxygen
hose
7-00189
Male
DISS
fitting
2
10
4
3
5
Air Liquide
oxygen
hose
7-00190
Male
DISS
fitting
10
6
7
10
NIST
oxygen
hose
OXYGEN
7-00191

Figure 9-9. Oxygen hose adapters

9.11 Label kit

Label kit parts list

Item no. (Figure 9-10)	Part no.	Quantity	Description
--	G-061388-00	--	Label kit, English, *740* Ventilator
	G-061390-00	--	Label kit, French, *740* Ventilator
	G-061389-00	--	Label kit, German, *740* Ventilator
	G-061391-00	--	Label kit, Italian, *740* Ventilator
	G-061395-00	--	Label kit, Japanese, *740* Ventilator
	G-061394-00	--	Label kit, Polish, *740* Ventilator
	G-061393-00	--	Label kit, Portuguese, *740* Ventilator
	G-061396-00	--	Label kit, Russian, *740* Ventilator
	G-061392-00	--	Label kit, Spanish, *740* Ventilator
	G-062172-00	--	Label kit, Dutch, *760* Ventilator
	G-062164-00	--	Label kit, English, *760* Ventilator
	G-062165-00	--	Label kit, French, *760* Ventilator
	G-062160-00	--	Label kit, German, *760* Ventilator
	G-062167-00	--	Label kit, Italian, *760* Ventilator
	G-062171-00	--	Label kit, Japanese, *760* Ventilator
	G-062169-00	--	Label kit, Polish, *760* Ventilator
	G-062189-00	--	Label kit, Portuguese, *760* Ventilator
	G-062170-00	--	Label kit, Russian, *760* Ventilator
	G-062168-00	--	Label kit, Spanish, *760* Ventilator
1	--	1	• Label, oxygen inlet port
2	--	1	• Label, main fan filter
3	--	1	• Label, air intake
4	--	1	• Label, life support
5	--	1	• Label, patient circuit expiratory port
6	--	1	• Label, patient circuit inspiratory port
7	--	1	• Label, back panel
8	--	1	• Label, on/off switch
9	--	1	• Label, circuit breaker
10	--	1	• Label, external battery

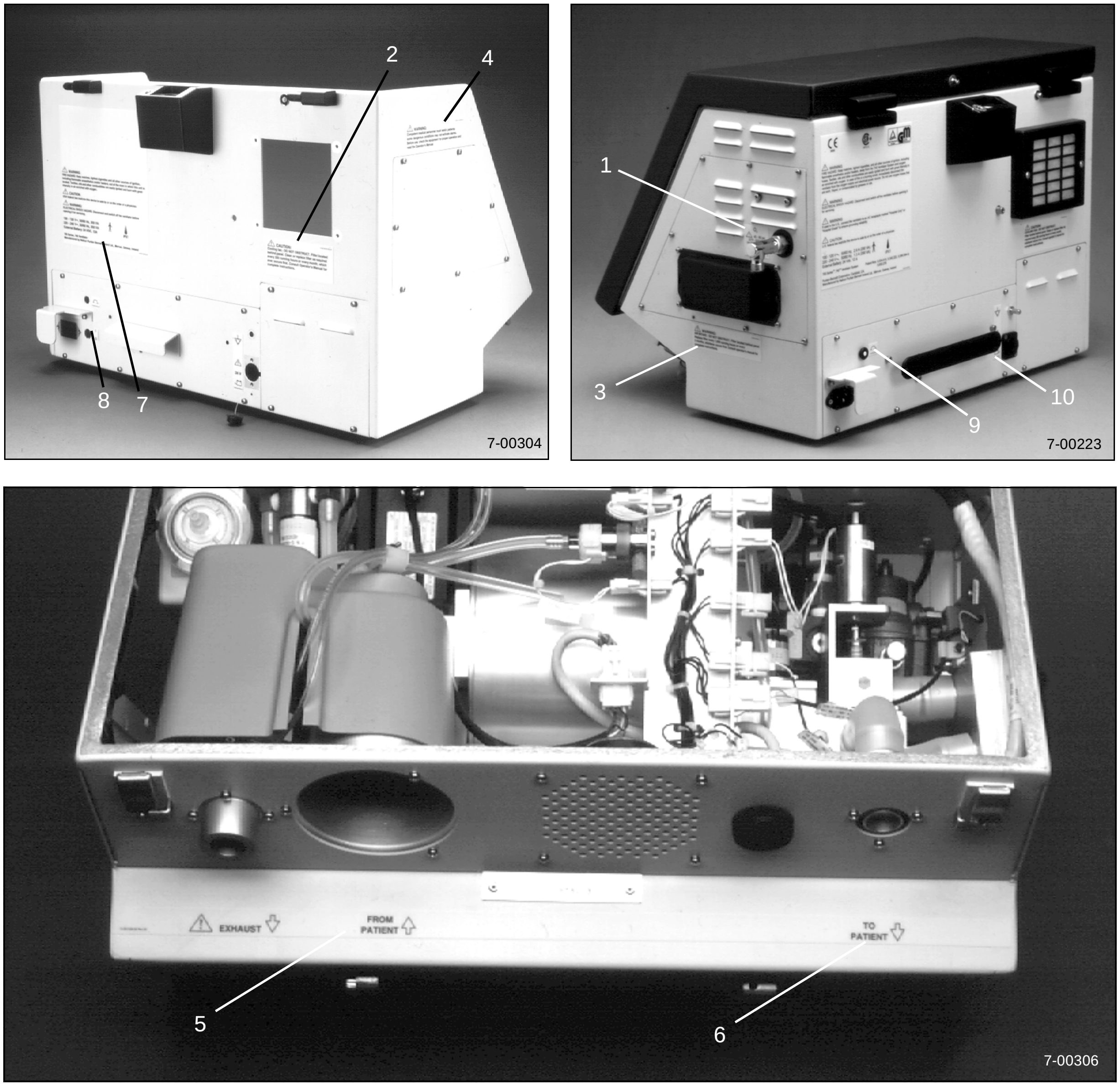
2
4
8
7
7-00304
1
3
10
9
7-00223
EXHAUST
FROM PATIENT
TO PATIENT
5
6
7-00306

Figure 9-10. Label kit

9.12 Inspiration manifold assembly

Inspiration manifold assembly parts list

Item no. (Figure 9-11)	Part no.	Quantity	Description
--	--	--	Inspiration manifold assembly
1	G-062162-00	1	Inspiration manifold
2	G-062010-00	1	• Oxygen sensor (includes oxygen sensor only)
	G-062009-00	1	• Oxygen sensor kit (includes oxygen sensor, sensor harness, adapter, and hardware; replaces sensor with integral harness)
3	G-061257-00	1	• Safety valve assembly
4	G-060072-00	1	• • Seat, safety valve (not shown)
5	G-060976-00	4	• Screw, SOC, M3 x 8 (Attaches safety valve)
6	G-060995-00	4	• Washer, SR, M3 (Attaches safety valve)
7	G-060095-00	1	• Thermistor, inspiration manifold
8	G-061031-00	4	Screw, SOC, M3 x 10 (Attaches inspiration manifold)
9	G-060995-00	4	Washer, SR, M3 (Attaches inspiration manifold)
10	G-061250-00	1	Check valve, cylinder outlet (blue housing)
11	G-060045-00	1	Gasket, check valve
12	G-061031-00	4	Screw, SOC, M3 x 10 (Attaches oxygen sensor holder to inspiration manifold)
13	G-060995-00	4	Washer, SR, M3 (Attaches oxygen sensor holder to inspiration manifold)
14	G-060043-00	1	Inspiratory port assembly

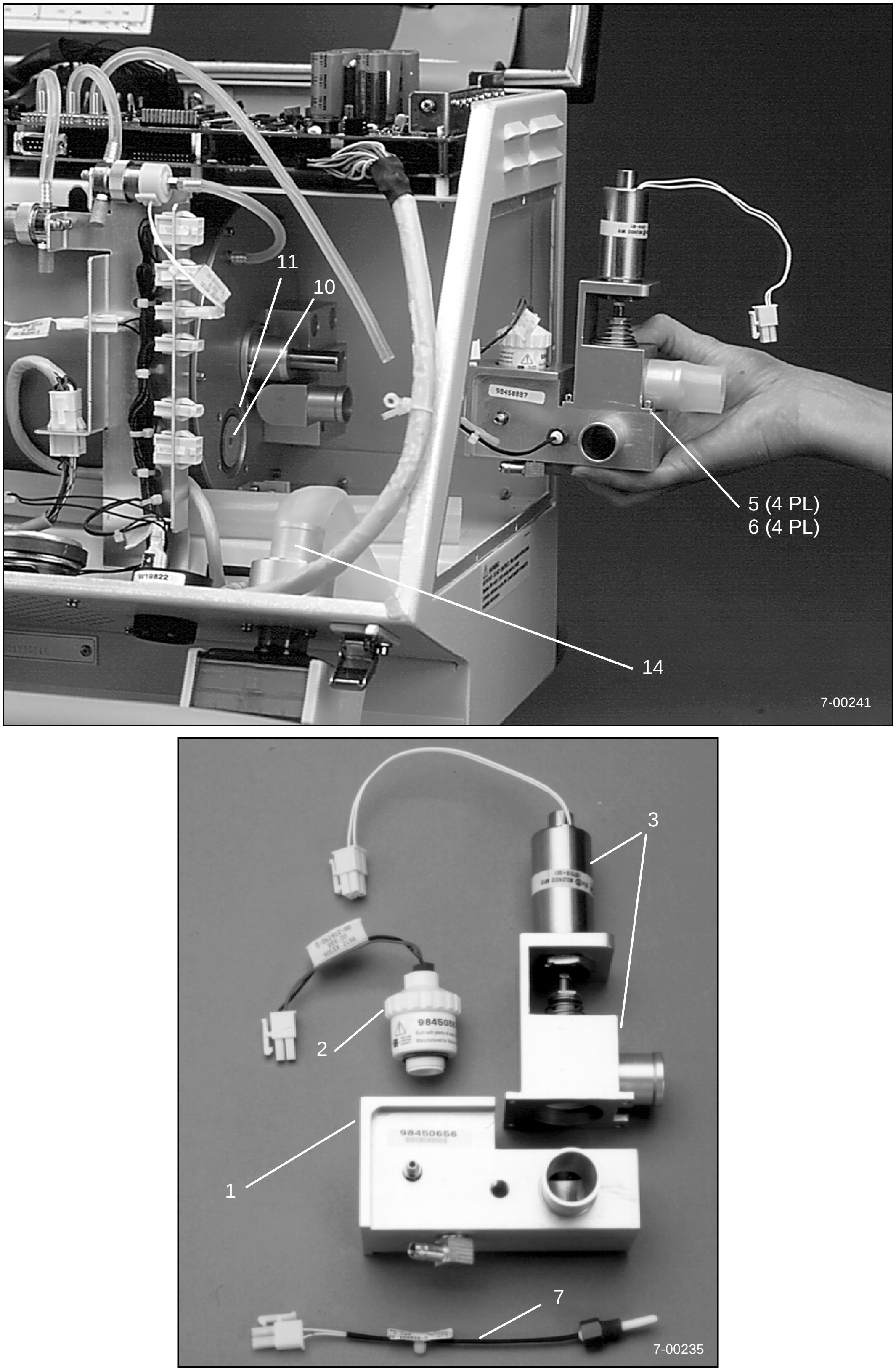
11
10
5 (4 PL)
6 (4 PL)
14
7-00241
3
2
1
7
7-00235

Figure 9-11. Inspiration manifold assembly

9.13 Oxygen regulator and oxygen solenoid assembly

Oxygen regulator assembly parts list

Item no. (Figure 9-12)	Part no.	Quantity	Description
1	G-062022-00	1	Regulator, oxygen
2	4-019063-00	1	• Fitting, oxygen, DISS male
3	G-062023-00	1	Oxygen solenoid assembly
4	--	10.7 cm	Tube, silicone, 3/4-in. ID x 1-in. OD (Part of tube kit, P/N G-061406-00 (Section 9.21)) (for use with older air intake manifold assembly G-060217-00)
		10.5 cm	Tube, silicone, 3/4-in. ID x 1-in. OD (Part of tube kit, P/N G-061406-00 (Section 9.21)) (for use with newer air intake manifold assembly G-062026-00)
5	G-062293-00	1	Manifold assembly, mixing
6	G-061031-00	4	Screw, SOC, M3 x 10 (Attaches mixing manifold)
7	G-060995-00	4	Washer, SR, M3 (Attaches mixing manifold)
8	G-061694-00	1	Transducer, pressure, oxygen regulator
9	G-060759-00	A/R	Tape, PTFE (Used on threads of oxygen fitting, oxygen regulator pressure transducer, and oxygen regulator extension adapter)
10	G-061251-00	1	Check valve, cylinder inlet (white housing) (not shown)
11	G-060045-00	1	Gasket, check valve (not shown)
12	G-061264-00	1	Adapter, oxygen pressure transducer

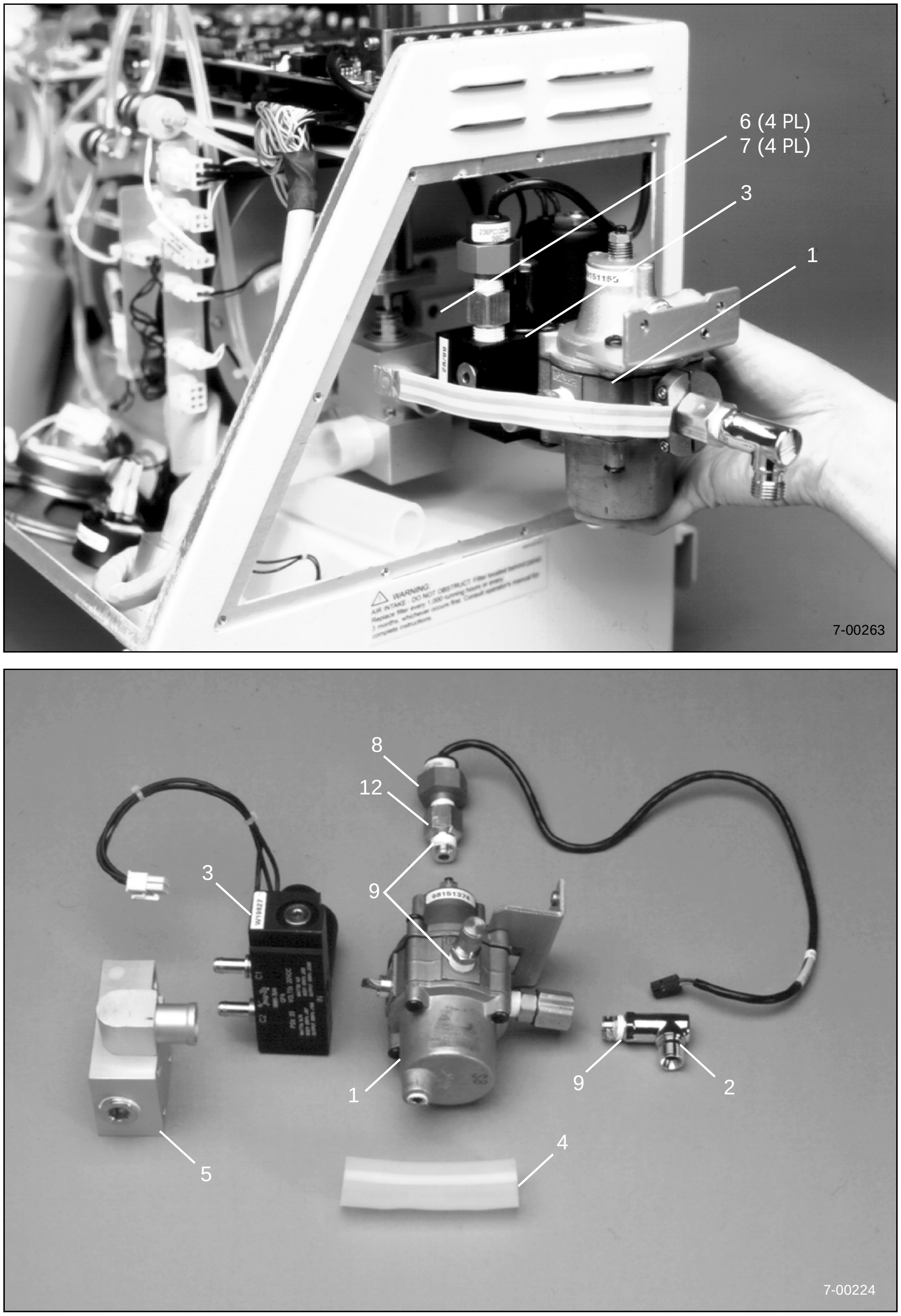
6 (4 PL)
7 (4 PL)
3
1
7-00263
8
12
3
9
1
9
2
4
5
7-00224

Figure 9-12. Oxygen regulator and oxygen solenoid assembly

9.14 Exhalation assembly

Exhalation assembly parts list

Item no. (Figure 9-13)	Part no.	Quantity	Description
--	--	--	Exhalation assembly
1	G-061526-00	1	• Valve assembly, exhalation
2	--		• • Valve, exhalation
3	G-060823-00	1	• • O-ring, exhalation valve (not shown)
4	G-060976-00	9	• Screw, SOC, M3 x 8 (Attaches exhalation valve to flow sensor; attaches exhalation valve to cross tube; attaches check valve to expiratory filter housing)
5	G-060995-00	9	• Washer, SR, M3 (Attaches exhalation valve to flow sensor; attaches exhalation valve to cross tube; attaches check valve to expiratory filter housing)
6	G-061023-00	1	• Block, exhalation cross tube
7	G-060921-00	1	• Clip, cross tube heater (spring)
8	G-060979-00	3	• Screw, SOC, M4 x 12 (Retains check valve)
9	G-060996-00	3	• Washer, SR, M4 (Retains check valve)
10	G-061693-00	1	• Heater assembly, exhalation
11	G-060210-00	1	• Housing, expiratory filter
12	G-060045-00	1	• Gasket, check valve
13	G-061252-00	1	• Check valve, exhalation
14	G-061144-00	1	• Flow sensor assembly
15	G-060844-00	1	• Thermistor assembly, exhalation
16	G-060922-00	1	• Clip, flow sensor heater (spring)
17	G-061122-00	7	Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches flow sensor assembly and expiratory filter housing to cabinet) (not shown)
18	G-062315-00	1	Exhalation check valve housing, lower
19	--	--	Not used
20	G-061055-00	3	Nut, HEX, with washer, EX LK, M3 (Attaches expiratory filter housing to cabinet)
21	G-060489-00	1	Cover, exhalation assembly insulation
22	G-061202-00	1	Screw, SOC, M5 x 12 (Attaches exhalation assembly cover)
23	G-060999-00	1	Washer, flat, M5 (Attaches exhalation assembly cover)

Exhalation assembly parts list (continued)

Item no. (Figure 9-13)	Part no.	Quantity	Description
24	G-061067-00	1	Clip, exhalation cover
25	G-061087-00	1	Tube assembly, flow sensor

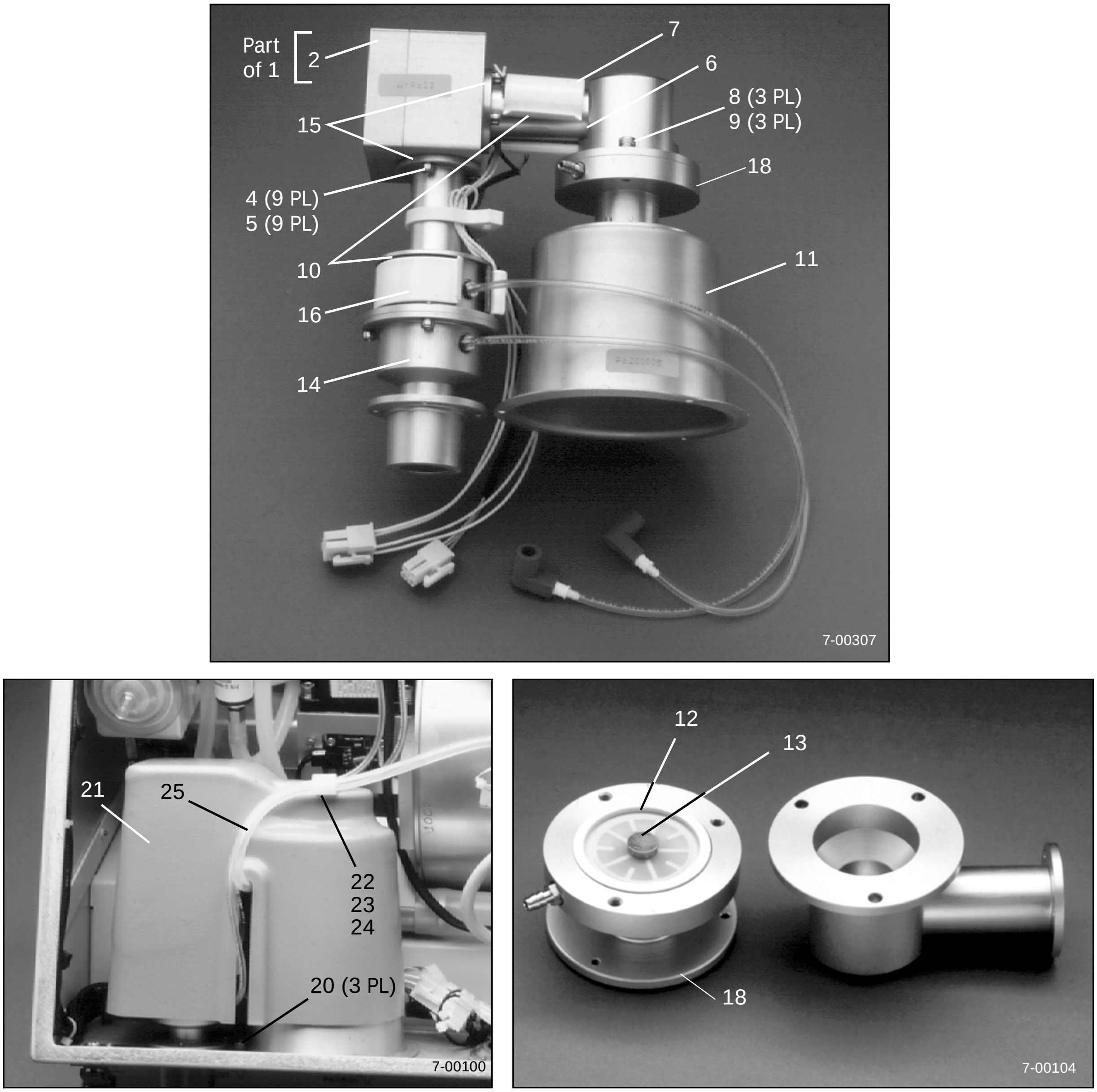
Part of 1
2
7
6
8 (3 PL)
9 (3 PL)
15
18
4 (9 PL)
5 (9 PL)
10
11
16
14
7-00307
21
25
22
23
24
20 (3 PL)
7-00100
12
13
18
7-00104

Figure 9-13. Exhalation assembly

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9.15 Cable management bar, PCBs, speaker, and piezo alarm

Cable management bar, PCBs, speaker, and piezo alarm parts list

Item no. (Figure 9-14)	Part no.	Quantity	Description
1	G-060924-00	1	Cable management bar
2	G-060990-00	1	Nut, HEX, M4 (Attaches bottom of cable management bar)
3	G-060996-00	2	Washer, SR, M4 (Attaches cable management bar)
4	G-060978-00	1	Screw, SOC, M4 x 8 (Attaches top of cable management bar) (not shown)
5	G-060104-00	1	Harness, ventilator head, main
6	G-060098-00	2	Solenoid, autozero (cylinder pressure transducer/ exhalation pressure transducer)
7	G-061203-00	4	Screw, SOC, 6-32 x 5/16 (Attaches autozero solenoids)
8	G-060996-00	4	Washer, SR, M4 (Attaches autozero solenoids)
9	G-060496-00	1	Speaker
10	G-061094-00	4	Screw, PAN, M3 x 12, POZIDRIV, with captive washers (Attaches speaker)
11	--	--	Not used
12	--	--	Not used
13	G-062138-00	1	Alarm, piezo (buzzer)
14	G-062146-00	1	PCB, controller (Does not include software EPROMs (item 22) or NVRAM (item 15).) (See Figure 9-15 for component locations.)
15	G-061686-00	1	NVRAM (nonvolatile RAM) (U6) (See Figure 9-15 for location.)
16	G-061127-00	1	PCB, pressure solenoid (See Figure 9-16 for component locations.)
17	G-060934-00	4	Post, HEX, mini-support (Attaches controller PCB) (not shown)
18	G-060505-00	7	Standoff, male-male, M3 x 10 (Attaches controller PCB)
19	G-061410-00	7	Standoff, male-female, M3 x 17 (Attaches pressure solenoid PCB)
20	G-061677-00	7	Standoff, M3 (Attaches pressure solenoid PCB)
21	G-060995-00	7	Washer, SR, M3 (Attaches pressure solenoid PCB)

Cable management bar, PCBs, speaker, and piezo alarm parts list (continued)

Item no. (Figure 9-14)	Part no.	Quantity	Description
22	G-061397-00	1	EPROM kit, English, non-U.S. (not shown) (See Figure 9-15 for component locations.)
	G-061961-00	1	EPROM kit, U.S. English (not shown) (See Figure 9-15 for component locations.)
	G-061399-00	1	EPROM kit, French (not shown) (See Figure 9-15 for component locations.)
	G-061398-00	1	EPROM kit, German (not shown) (See Figure 9-15 for component locations.)
	G-061400-00	1	EPROM kit, Italian (not shown) (See Figure 9-15 for component locations.)
	G-061404-00	1	EPROM kit, Japanese (not shown) (See Figure 9-15 for component locations.)
	G-061403-00	1	EPROM kit, Polish (not shown) (See Figure 9-15 for component locations.)
	G-061402-00	1	EPROM kit, Portuguese (not shown) (See Figure 9-15 for component locations.)
	G-061405-00	1	EPROM kit, Russian (not shown) (See Figure 9-15 for component locations.)
	G-061401-00	1	EPROM kit, Spanish (not shown) (See Figure 9-15 for component locations.)
23	G-061096-00	2	Cable tie, small (Attaches main ventilator head harness to cable management bar)

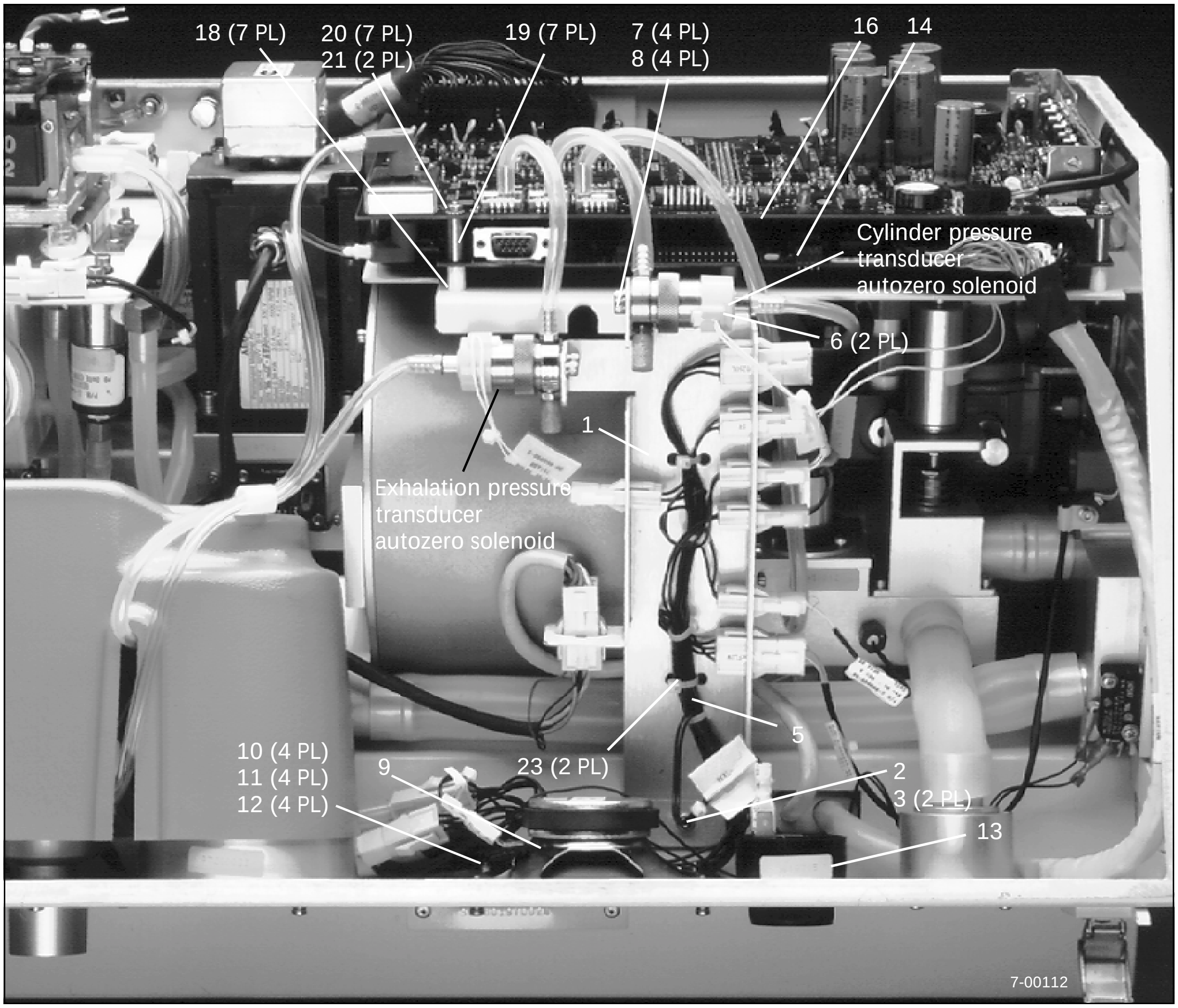
18 (7 PL)
20 (7 PL)
21 (2 PL)
19 (7 PL)
7 (4 PL)
8 (4 PL)
16
14
Cylinder pressure transducer autozero solenoid
6 (2 PL)
1
Exhalation pressure transducer autozero solenoid
5
10 (4 PL)
11 (4 PL)
12 (4 PL)
9
23 (2 PL)
2
3 (2 PL)
13
7-00112

Figure 9-14. Cable management bar, PCBs, speaker, and piezo alarm

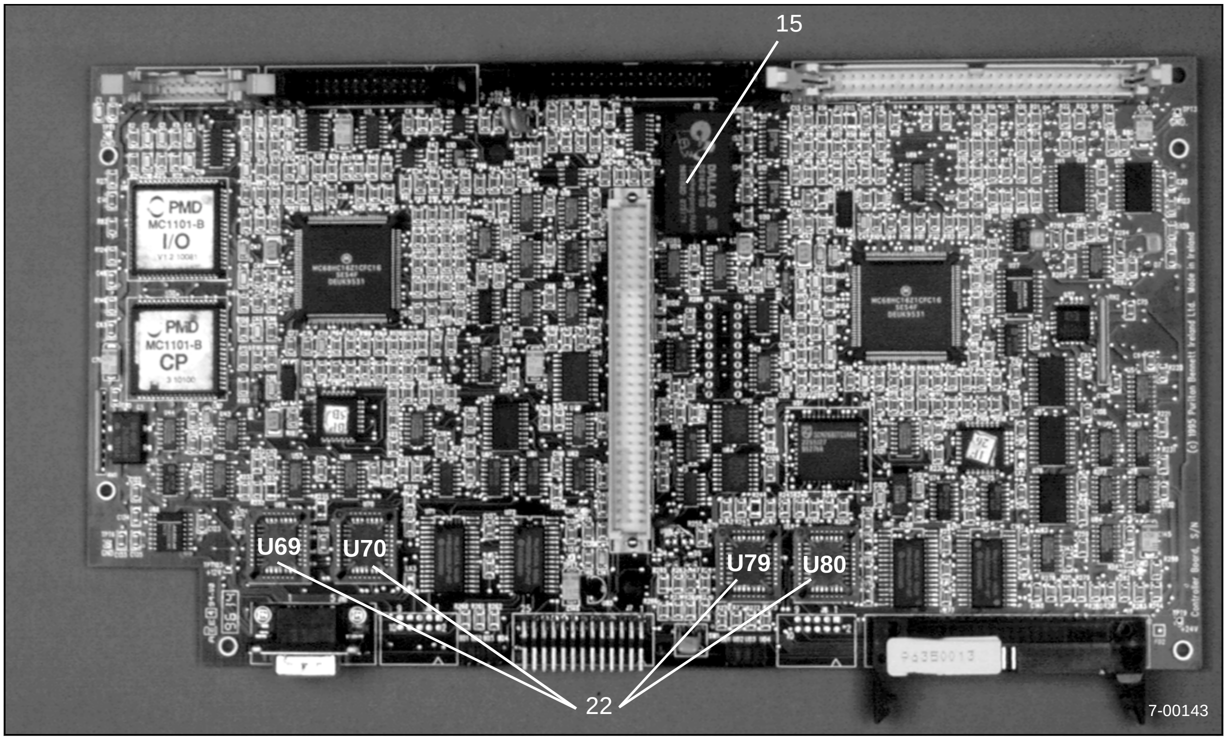
15
U69
U70
U79
U80
22
7-00143

Figure 9-15. Controller PCB component locations

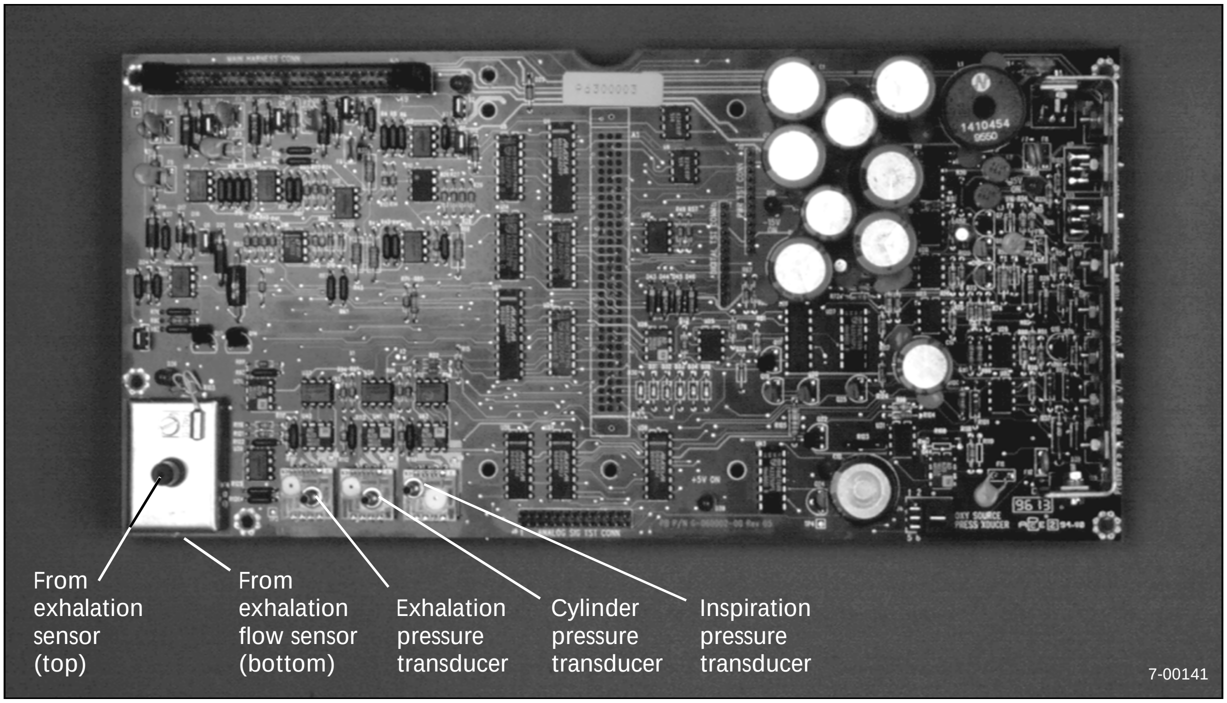
From exhalation sensor (top)
From exhalation flow sensor (bottom)
Exhalation pressure transducer
Cylinder pressure transducer
Inspiration pressure transducer
7-00141

Figure 9-16. Pressure solenoid PCB component locations

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9.16 PEEP pump and reservoir

PEEP pump and reservoir parts list

Item no. (Figure 9-17)	Part no.	Quantity	Description
1	G-061133-00	1	Pump, vibrating armature (PEEP)
2	G-060990-00	4	Nut, HEX, M4 (Attaches PEEP pump)
3	G-060996-00	4	Washer, SR, M4 (Attaches PEEP pump)
4	G-061431-00	1	Reservoir assembly, PEEP
5	--	1	• Reservoir
6	--	2	• Tube, silicone, 3-mm ID x 6-mm OD, 16.0 cm (Part of tube kit, P/N G-061407-00 (Section 9.21))
7	--	1	• Tube, silicone, 3/16-in. ID x 3/8-in. OD, 13.0 cm (Part of tube kit, P/N G-061408-00 (Section 9.21))
8	--	1	• Tube, silicone, 3/16-in. ID x 3/8-in. OD, 20.0 cm (Part of tube kit, P/N G-061408-00 (Section 9.21))
9	4-011905-00	1	• Filter (PEEP pump air intake)
10	G-060978-00	2	Screw, SOC, M4 x 8 (Attaches PEEP reservoir)
11	G-060996-00	2	Washer, SR, M4 (Attaches PEEP reservoir)
12	G-060090-00	1	Solenoid, exhalation (PEEP)
13	G-061149-00	2	Screw, SOC, M4 x 14 (Attaches exhalation solenoid)
14	G-061028-00	2	Washer, flat, M4 (Attaches exhalation solenoid)
15	G-061069-00	2	Grommet, exhalation solenoid mounting
16	G-061096-00	2	Cable tie, small (Attaches exhalation solenoid harness and PEEP pump harness to ventilator head harness)

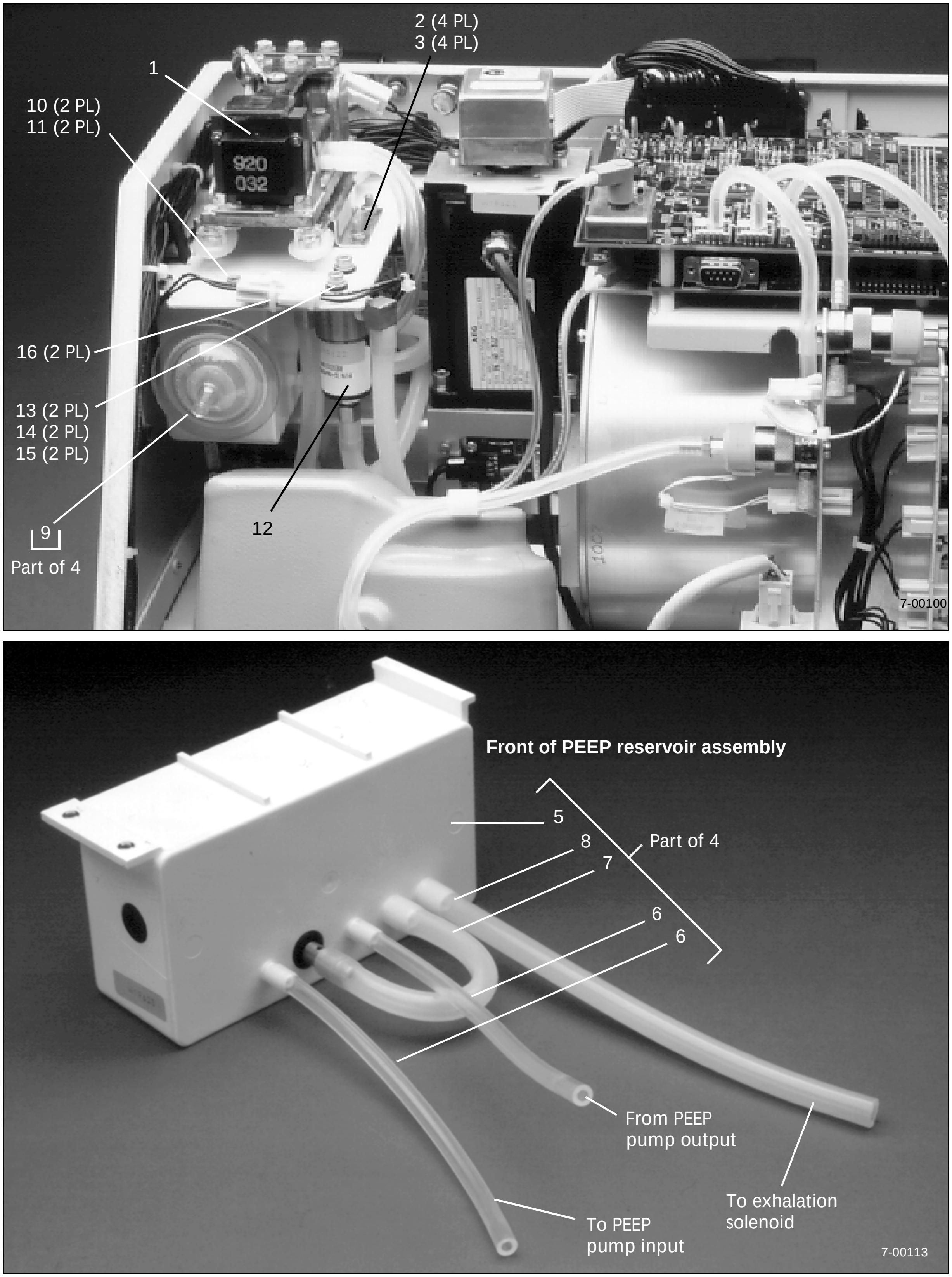
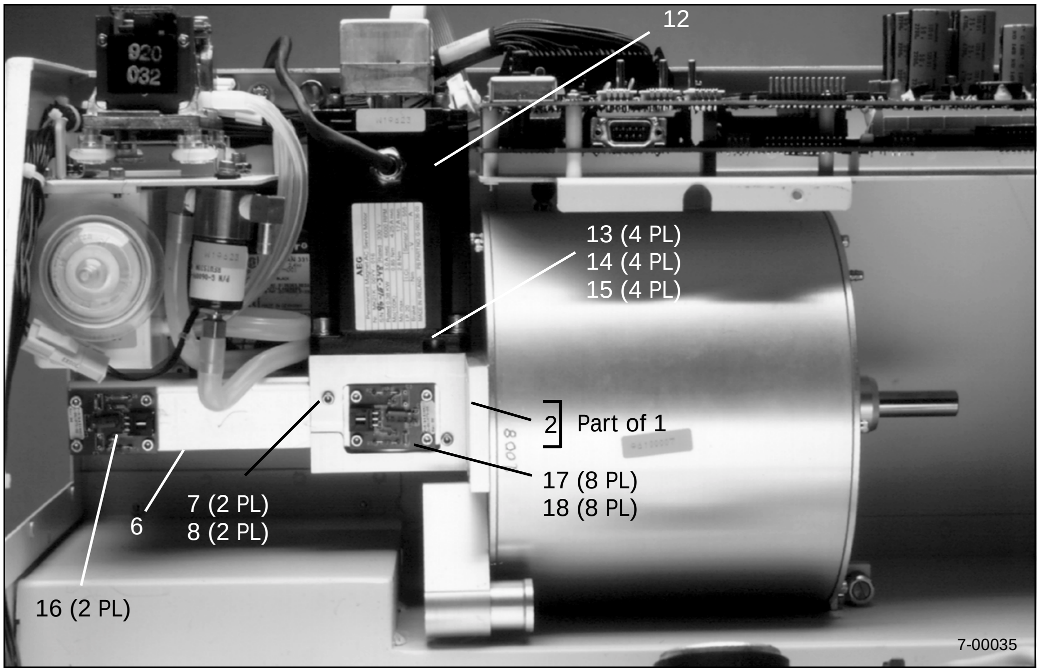

2 (4 PL)
3 (4 PL)
1
10 (2 PL)
11 (2 PL)
16 (2 PL)
13 (2 PL)
14 (2 PL)
15 (2 PL)
9
Part of 4
12
7-00100
Front of PEEP reservoir assembly
5
8
7
Part of 4
6
6
From PEEP pump output
To exhalation solenoid
To PEEP pump input
7-00113

Figure 9-17. PEEP pump and reservoir

9.17 Piston/cylinder and motor/encoder assemblies

Piston/cylinder and motor/encoder assemblies parts list

Item no. (Figure 9-18)	Part no.	Quantity	Description
1	G-061134-00	1	Piston/cylinder assembly
2	--	1	• Bracket, motor angle
3	G-061251-00	1	• Check valve, cylinder inlet (white housing)
4	G-061250-00	1	• Check valve, cylinder outlet (blue housing)
5	G-060045-00	2	• Gasket, check valve
6	G-062161-00	1	Cover, rack
7	G-060977-00	3	Screw, SOC, M3 x 12 (Attaches rack cover to piston/cylinder)
8	G-060995-00	3	Washer, SR, M3 (Attaches rack cover to piston/cylinder)
9	G-061202-00	1	Screw, SOC, M5 x 12, POZIDRIV (Attaches piston/cylinder to cabinet)
10	G-060999-00	1	Washer, flat, M5 (Attaches piston/cylinder to cabinet)
11	G-060997-00	1	Washer, SR, M5 (Attaches piston/cylinder to cabinet)
12	G-061138-00	1	Motor/encoder assembly
13	G-061039-00	4	Screw, SOC, M5 x 20 (Attaches motor/encoder)
14	G-060997-00	4	Washer, SR, M5 (Attaches motor/encoder)
15	G-060999-00	4	Washer, flat, M5 (Attaches motor/encoder)
16	G-061255-00	2	Optoswitch (motor-opto) assembly
17	G-060976-00	8	Screw, SOC, M3 x 8 (Attaches optoswitch)
18	G-060995-00	8	Washer, SR, M3 (Attaches optoswitch)
19	--	30 cm	Tube, silicone, 3/4-in. ID x 1-in. OD (Part of tube kit, P/N G-061406-00 (Section 9.21)) (not shown)
20	G-060532-00	A/R	Grease, 10 grams (not shown)


12
13 (4 PL)
14 (4 PL)
15 (4 PL)
2 Part of 1
17 (8 PL)
18 (8 PL)
7 (2 PL)
8 (2 PL)
6
16 (2 PL)
7-00035

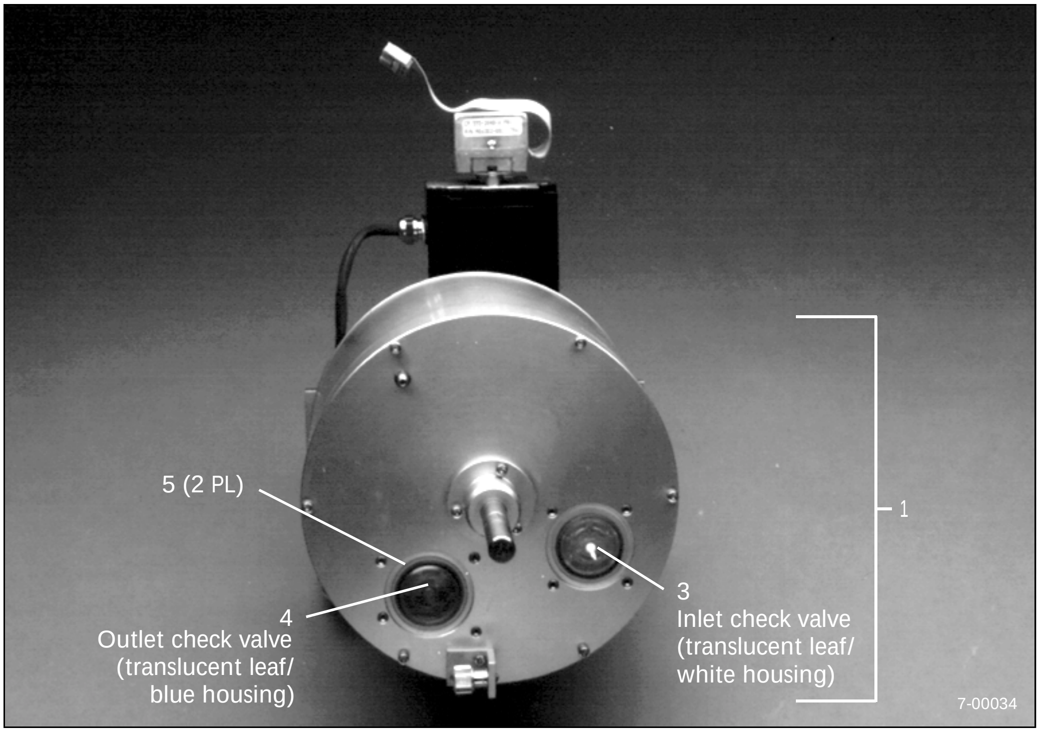

5 (2 PL)
1
3
Inlet check valve
(translucent leaf/
white housing)
4
Outlet check valve
(translucent leaf/
blue housing)
7-00034

Figure 9-18. Piston/cylinder and motor/encoder assemblies (Sheet 1 of 2)

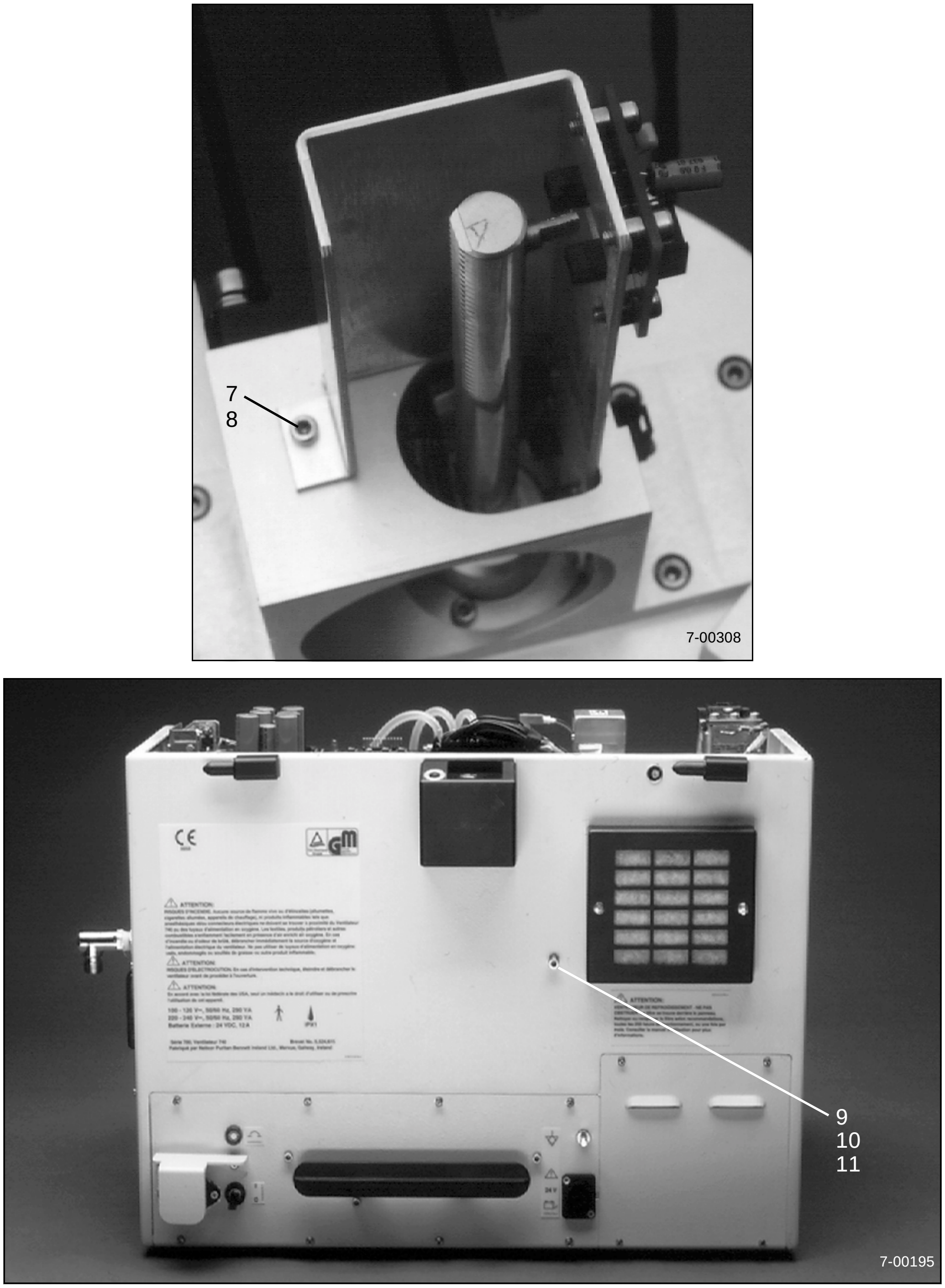

7
8
7-00308
9
10
11
7-00195

Figure 9-18. Piston/cylinder and motor/encoder assemblies (Sheet 2 of 2)

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9.18 Ventilator rear components

Ventilator rear components parts list

Item no. (Figure 9-19)	Part no.	Quantity	Description
1	G-061139-00	1	Battery, internal
2	--	1	Power assembly (See Section 9.19 for parts breakdown.)
3	G-061094-00	8	Screw, PAN, M3 x 12, POZIDRIV, with captive washers (Attaches power assembly)
4	G-060447-00	1	Back panel,
5	G-061340-00	1	Cord wrap
6	G-060129-00	1	Fan, main
7	--	--	Cover, fan filter (part of fan guard assembly, item 9)
8	G-061263-00	1	Filter, fan (package of 6)
9	G-060834-00	1	Fan guard assembly (includes fan filter cover and fan guard)
10	G-061122-00	4	Screw, PAN, M3 x 8, POZIDRIV, with captive washers (Attaches fan/fan guard to ventilator)
11	G-061942-00	1	Power cord retainer kit
12	G-061031-00	4	Screw, SOC, M3 x10 (Attaches fan to fan guard)
13	G-060995-00	4	Washer, SR, M3 (Attaches fan to fan guard)
14	G-060998-00	4	Washer, flat, M3 (Attaches fan to fan guard)
15	G-060448-00	1	Plate, battery compartment access
16	G-061094-00	4	Screw, PAN, M3 x 12, POZIDRIV, with captive washers (Attaches battery compartment access plate)
17	--	--	Not used
18	--	--	Not used
19	G-061096-00	1	Cable tie, small (Attaches fan harness to ventilator head harness) (not shown)

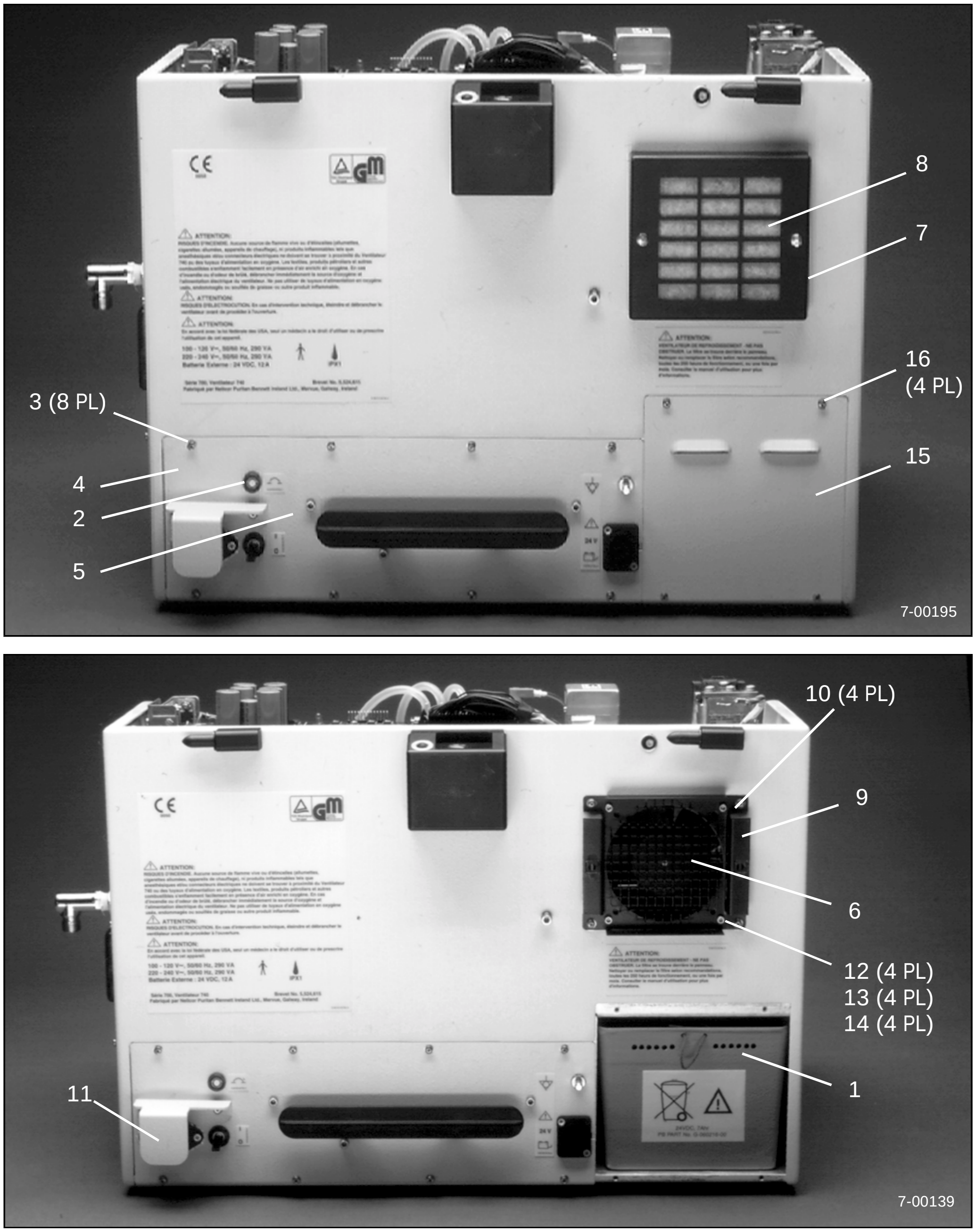

8
7
16
(4 PL)
3 (8 PL)
15
4
2
5
7-00195
10 (4 PL)
9
6
12 (4 PL)
13 (4 PL)
14 (4 PL)
11
1
7-00139

Figure 9-19. Ventilator rear components

9.19 Power assembly

Power assembly parts list

Item no. (Figure 9-20)	Part no.	Quantity	Description
--	--	--	Power assembly
1	G-060113-00	1	• Harness, external battery
2	G-060986-00	2	• Screw, FH, M3 x 8, POZIDRIV (Attaches external battery harness)
3	G-060979-00	3	• Screw, SOC, M4 x 12 (Attaches power supply to back panel)
4	G-060996-00	3	• Washer, SR, M4 (Attaches power supply to back panel)
5	G-061131-00	1	• Power supply, 120/230 V, *740/760* Ventilators (230 V regions, all languages)
	G-062334-00	1	• Power supply, 120 V, *740/760* Ventilators (120 V regions, English)
	G-062336-00	1	• Power supply, 120 V, *740/760* Ventilators (120 V regions, Spanish)
	G-062344-00	1	• Power supply, 120 V, *740/760* Ventilators (120 V regions, French)
	G-062346-00	1	• Power supply, 120 V, *740/760* Ventilators (120 V regions, Japanese)
	G-062348-00	1	• Power supply, 120 V, *740/760* Ventilators (120 V regions, Portuguese)
6	G-060987-00	4	• Screw, FH, M4 x 6, POZIDRIV (Attaches power supply from bottom) (not shown)
7	G-060031-00	1	• Switch, power
8	G-060033-00	1	• Circuit breaker
9	G-061085-00	1	• Line filter
10	G-060986-00	2	• Screw, FH, M3 x 8, POZIDRIV (Attaches line filter)
11	G-061942-00	1	• Power cord retainer kit
12	G-061122-00	1	• Screw, PAN, M3 x 8, POZIDRIV, with captive washers (Attaches power cord retainer) (not shown)
13	--	--	• Not used
14	G-060444-00	--	• Power tray
15	G-061182-00	1	• Rivet (Attaches power cord retainer)
16	G-060110-00	1	• Harness, circuit breaker/power switch
17	G-060111-00	1	• Harness, power switch/power supply
18	G-060116-00	1	• Harness, power switch/BBU PCB

Power assembly parts list (continued)

Item no. (Figure 9-20)	Part no.	Quantity	Description
19	G-060446-00	1	• Bracket, fan, power supply
20	G-060986-00	2	• Screw, FH, M3 x 8, POZIDRIV (Attaches power supply fan bracket to base)
21	G-060131-00	1	• Fan, power supply
22	G-060976-00	4	• Screw, SOC, M3 x 8 (Attaches power supply fan to bracket)
23	G-060995-00	4	• Washer, SR, M3 (Attaches power supply fan to bracket)
24	G-060998-00	4	• Washer, flat, M3 (Attaches power supply fan to bracket)
25	G-061129-00	1	• PCB, battery backup (BBU) (See Figure 9-21 for component locations.)
26	G-060293-00	1	• • Fuse, 10 A, fast-blow, F-type (F1) (See Figure 9-21 for location.)
27	G-060292-00	1	• • Fuse, 15 A, standard, T-type (F6) (See Figure 9-21 for location.)
28	G-061027-00	6	• Screw, SOC, M3 x 6 (Attaches BBU PCB)
29	G-060995-00	6	• Washer, SR, M3 (Attaches BBU PCB)
30	G-060989-00	6	• Nut, HEX, M3 (Attaches BBU PCB)
31	G-060517-00	2	• Heat bar, FET
32	G-061063-00	2	• Heat cap, FET
33	G-061024-00	4	• Screw, FH, M3 x 12, POZIDRIV (Attaches FET heat bars)
34	G-060535-00	6	• Standoff, male-female, M3 x 6 (Separates BBU PCB from power tray)
35	G-060918-00	1	• Heat bar, miniFET
36	G-061024-00	2	• Screw, FH, M3 x 12, POZIDRIV (Attaches miniFET heat bar)
37	G-060117-00	1	• Harness, power supply/BBU PCB
38	--	1	• Label, circuit breaker
39	--	1	• Power cord (See Section 9.20 for part numbers.) (not shown)
40	G-060990-00	1	• Nut, HEX, M4 (Attaches line filter ground wire) (not shown)
41	G-060994-00	1	• Washer, IN LK, M4 (Attaches line filter ground wire) (not shown)
42	G-061028-00	1	• Washer, flat, M4 (Attaches line filter ground wire) (not shown)
43	G-060445-00	1	• Baffle, power supply

Power assembly parts list (continued)

Item no. (Figure 9-20)	Part no.	Quantity	Description
44	G-060979-00	2	• Screw, SOC, M4 x 12 (Attaches baffle to power supply)
45	G-060996-00	2	• Washer, SR, M4 (Attaches baffle to power supply)
46	G-061086-00	1	• Wire, ground, line filter (not shown)
47	--	1	• Label, battery connection and potential equalization port
48	G-061096-00	2	• Cable tie, small (Attaches power switch/BBU PCB harness to baffle)
49	G-060937-00	2	• Strip, thermal conductive
50	G-060110-00	1	• Harness, line filter/circuit breaker
51	G-061061-00	1	• Bracket, BBU PCB grommet
52	G-060986-00	2	• Screw, FH, M3 x 8, POZIDRIV (Retains BBU PCB grommet bracket)
53	G-060830-00	1	• Wire, ground, power input terminal (not shown)
54	G-060990-00	1	• Nut, HEX, M4 (Attaches power input terminal ground wire) (not shown)
55	G-061028-00	1	• Washer, flat, M4 (Attaches power input terminal ground wire) (not shown)
56	G-060994-00	1	• Washer, IN LK, M4 (Attaches power input terminal ground wire) (not shown)
57	G-060829-00	1	• Harness, internal battery (not shown)
58	G-060846-00	1	• Harness, BBU PCB/ventilator head
59	--	1	• Label, power switch

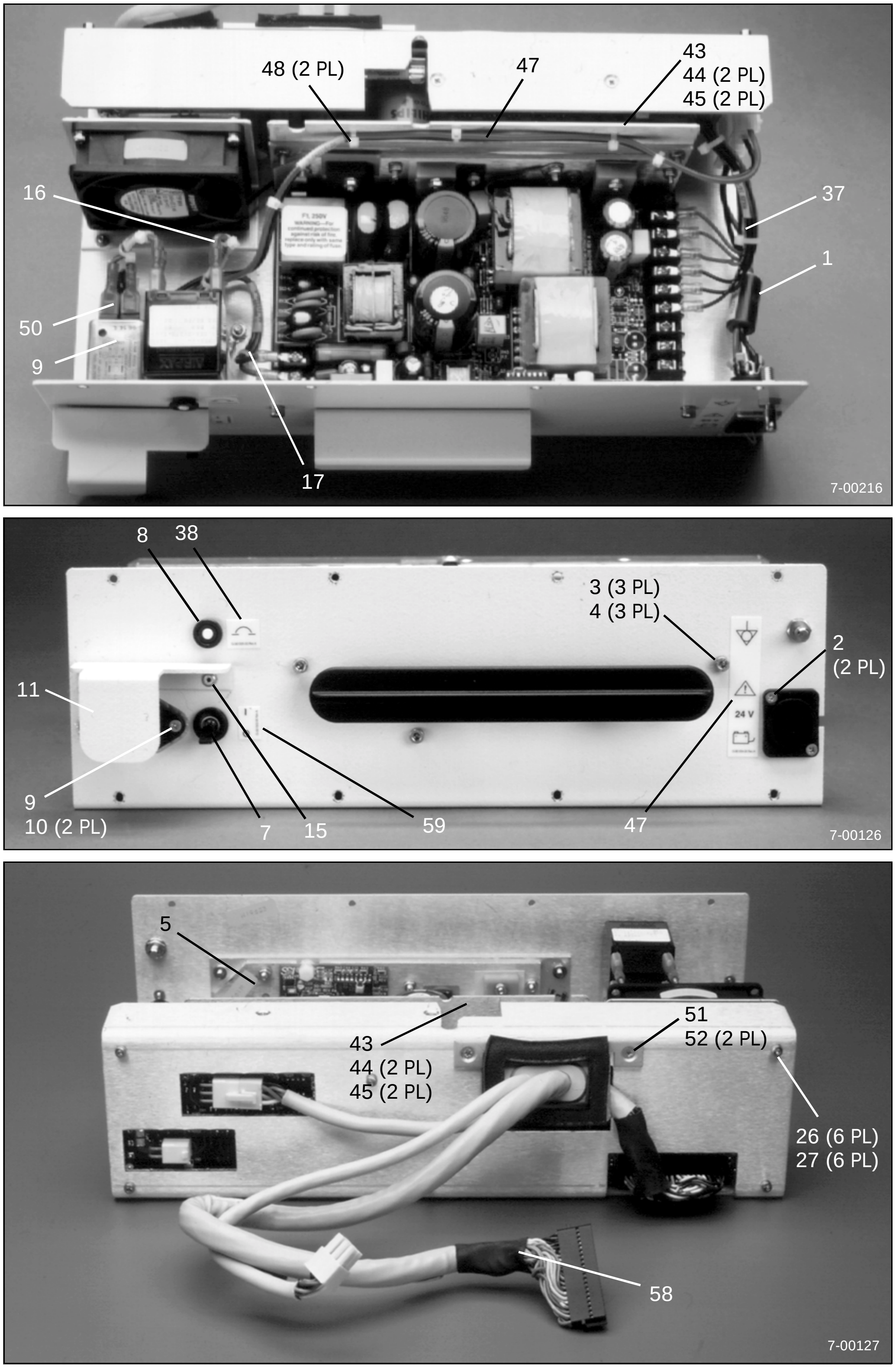
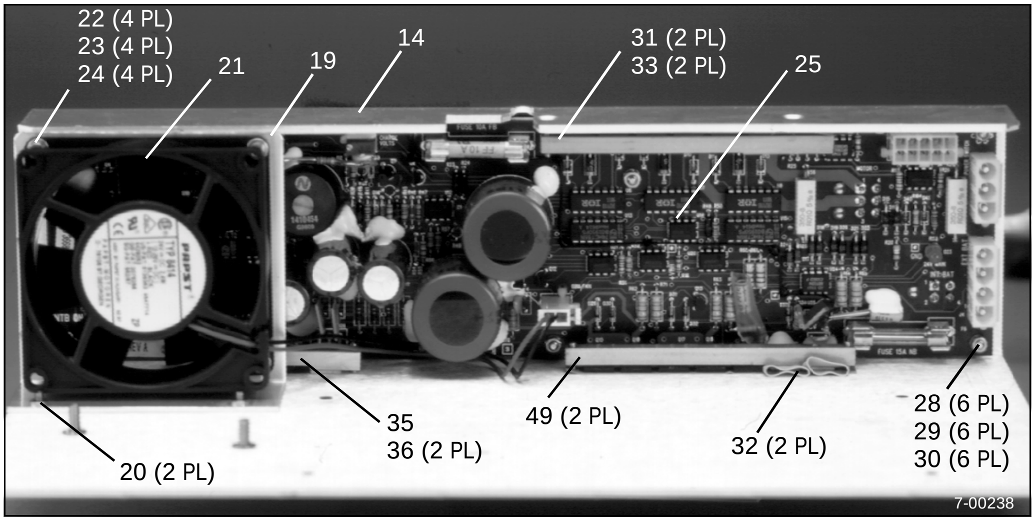
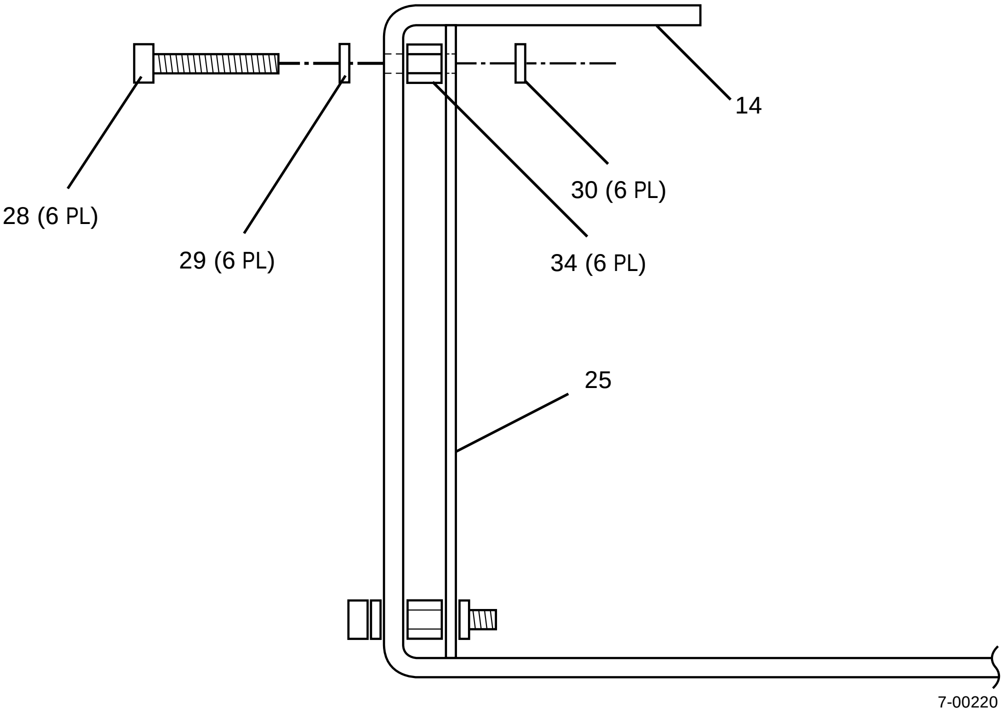

48 (2 PL)
47
43
44 (2 PL)
45 (2 PL)
16
37
1
50
9
17
7-00216
8
38
3 (3 PL)
4 (3 PL)
2
(2 PL)
11
9
10 (2 PL)
7
15
59
47
7-00126
5
51
52 (2 PL)
43
44 (2 PL)
45 (2 PL)
26 (6 PL)
27 (6 PL)
58
7-00127

Figure 9-20. Power assembly (Sheet 1 of 2)


22 (4 PL)
23 (4 PL)
24 (4 PL)
21
19
14
31 (2 PL)
33 (2 PL)
25
35
36 (2 PL)
49 (2 PL)
32 (2 PL)
28 (6 PL)
29 (6 PL)
30 (6 PL)
20 (2 PL)
7-00238


14
28 (6 PL)
29 (6 PL)
30 (6 PL)
34 (6 PL)
25
7-00220

BBU PCB mounting

Figure 9-20. Power assembly (Sheet 2 of 2)

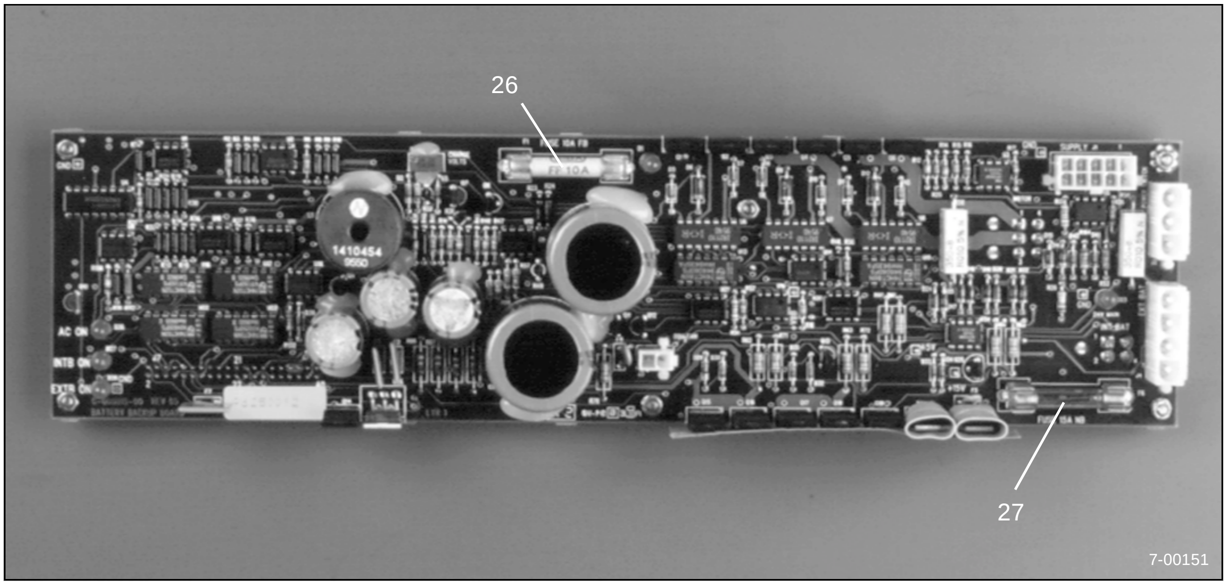


Figure 9-21. BBU PCB component locations

9.20 Power cords

Power cords parts list

Item no. (Figure 9-22)	Part no.	Quantity	Description
1	G-061241-00	1	Power cord, for North America/Japan
2	G-061242-00	1	Power cord, for Australia
3	G-061243-00	1	Power cord, for continental Europe
4	G-061247-00	1	Power cord, for India/South Africa (old, British-style plug with round prongs)
5	G-061248-00	1	Power cord, for Israel
6	G-061245-00	1	Power cord, for Italy
7	G-061246-00	1	Power cord, for Switzerland
8	G-060135-00	1	Power cord, for United Kingdom
9	G-061244-00	1	Power cord, for Denmark

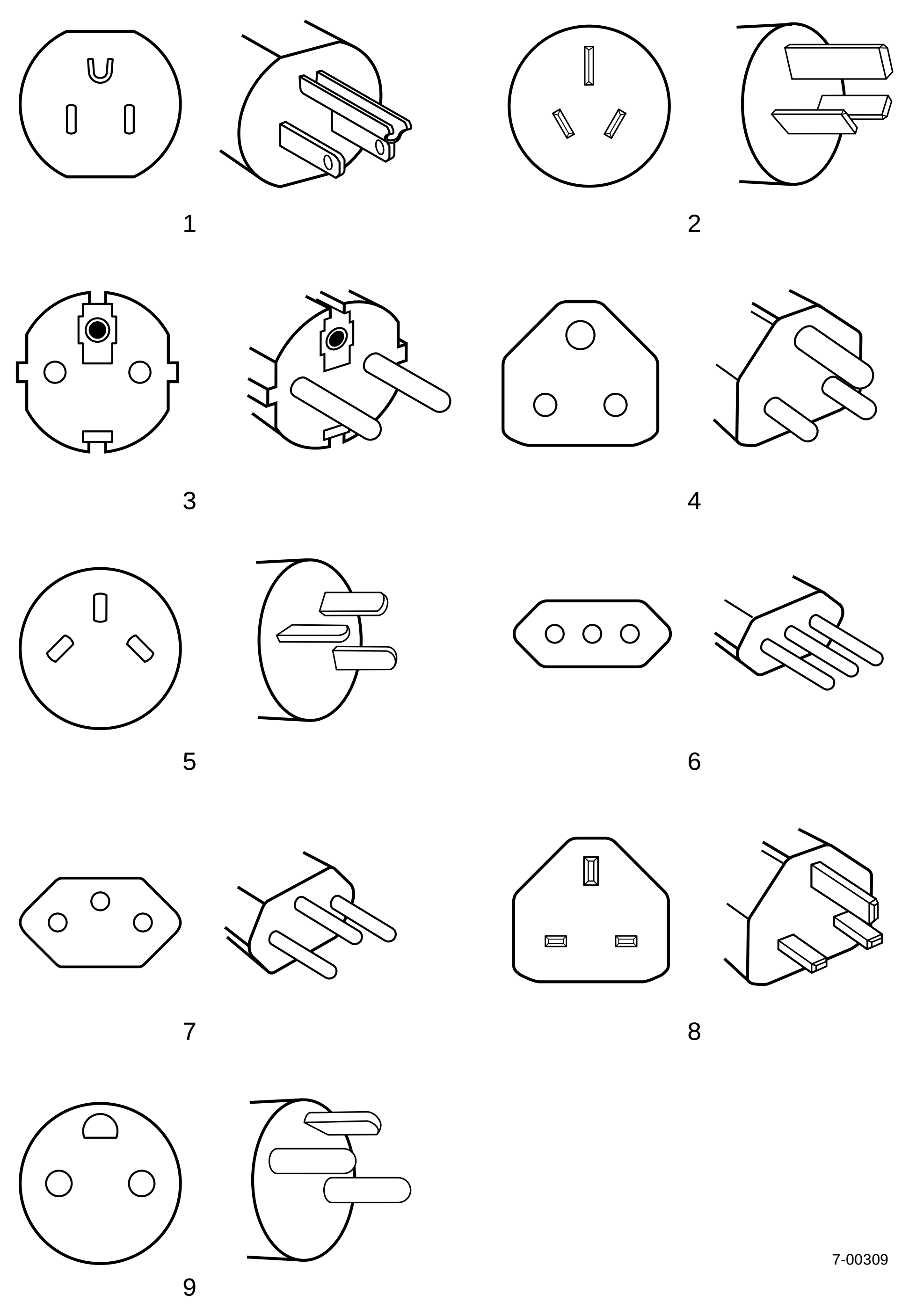

1
2
3
4
5
6
7
8
9
7-00309

Figure 9-22. Power cords

9.21 Tubing

Tubing parts list

Item no. (Figure 9-23)	Part no.	Quantity/ length	Description
1	G-061407-00	1	Tube kit, silicone, 3-mm ID x 6-mm OD, 65.5 cm (Can be cut to supply one each of the following 3-mm ID x 6-mm OD tubes) (G-060125-00) (not shown)
2	--	16.0 cm	• Tube, silicone, 3-mm ID x 6-mm OD
3	--	16.0 cm	• Tube, silicone, 3-mm ID x 6-mm OD
4	--	12.5 cm	• Tube, silicone, 3-mm ID x 6-mm OD
5	--	21.0 cm	• Tube, silicone, 3-mm ID x 6-mm OD
6	G-061408-00	1	Tube kit, silicone, 3/16-in. ID x 3/8-in. OD, 89.0 cm (Can be cut to supply one each of the following 3/16-in. ID x 3/8-in. OD tubes) (4-008575-00) (not shown)
7	--	13.0 cm	• Tube, silicone, 3/16-in. ID x 3/8-in. OD
8	--	20.0 cm	• Tube, silicone, 3/16-in. ID x 3/8-in. OD
9	--	16.0 cm	• Tube, silicone, 3/16-in. ID x 3/8-in. OD
10	--	40.0 cm	• Tube, silicone, 3/16-in. ID x 3/8-in. OD
11	G-061406-00	1	Tube kit, silicone, 3/4-in. ID x 1-in. OD, 45.2 cm (Can be cut to supply one each of the following 3/4-in. ID x 1-in. OD tubes) (G-060495-00) (not shown)
12	--	10.7 cm	• Tube, silicone, 3/4-in. ID x 1-in. OD (for use with older air intake manifold assembly G-060217-00)
	--	10.5 cm	• Tube, silicone, 3/4-in. ID x 1-in. OD (for use with newer air intake manifold assembly G-062026-00)
13	--	4.0 cm	• Tube, silicone, 3/4-in. ID x 1-in. OD
14	--	30 cm	• Tube, silicone, 3/4-in. ID x 1-in. OD
15	G-060767-00	1	Tube, silicone, 3/4-in. ID x 1-in. OD, elbow
16	G-061087-00	1	Tube assembly, flow sensor
17	G-061455-00	1	Tube kit, silicone, 1/8-in. ID x 1/4-in. OD, 49.5 cm (Can be cut to supply one each of the following 1/8-in. ID x 1/4-in. OD tubes) (4-008578-00) (not shown)
18	--	9.5 cm	• Tube, silicone, 1/8-in. ID x 1/4-in. OD
19	--	11.0 cm	• Tube, silicone, 1/8-in. ID x 1/4-in. OD
20	--	29.0 cm	• Tube, silicone, 1/8-in. ID x 1/4-in. OD

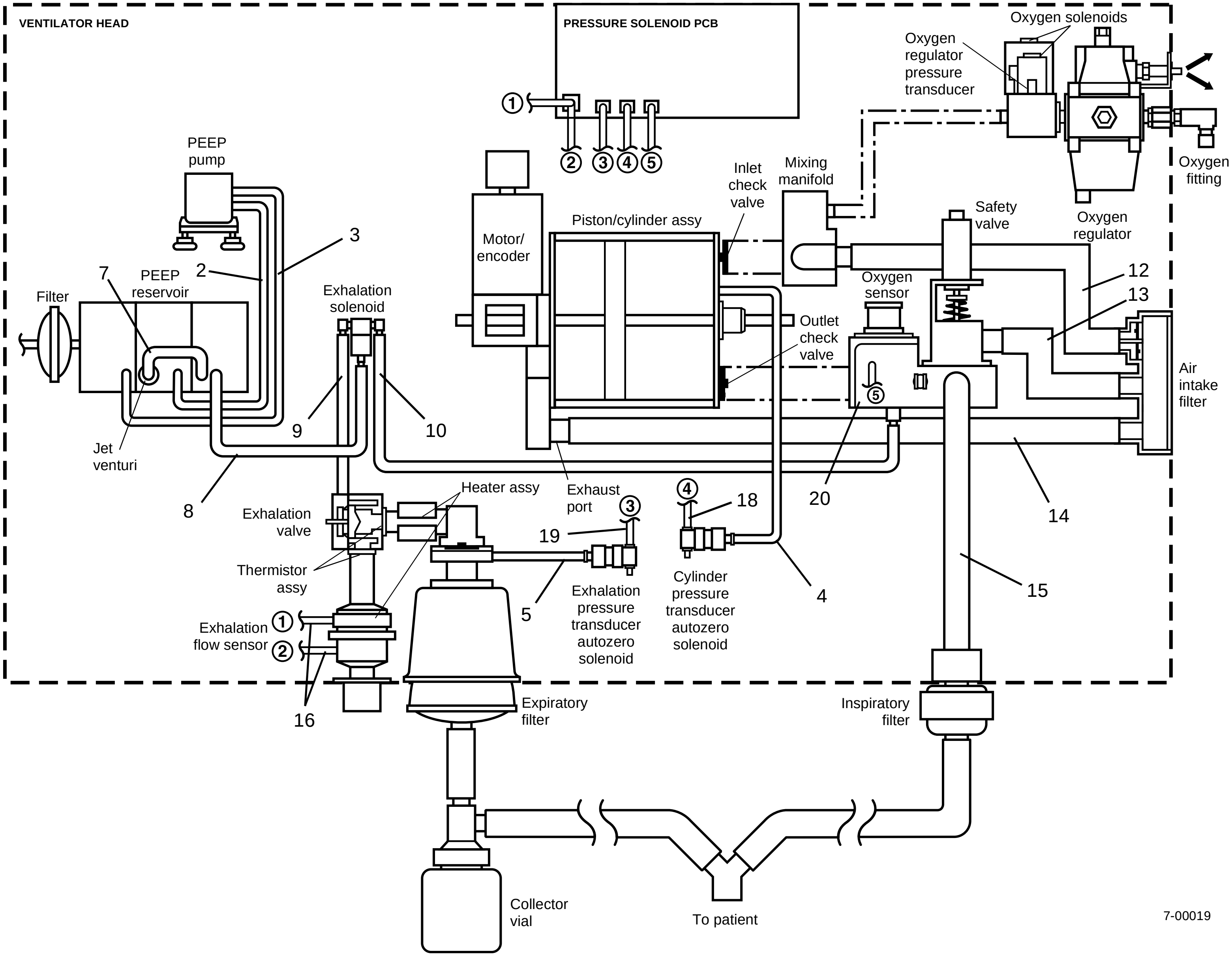

VENTILATOR HEAD
PRESSURE SOLENOID PCB
①
②
③
④
⑤
Oxygen solenoids
Oxygen regulator pressure transducer
Oxygen fitting
PEEP pump
3
2
7
PEEP reservoir
Filter
Motor/ encoder
Piston/cylinder assy
Inlet check valve
Mixing manifold
Safety valve
Oxygen regulator
12
13
Oxygen sensor
Outlet check valve
Exhalation solenoid
Air intake filter
9
10
Jet venturi
8
Heater assy
Exhaust port
③
④
18
20
14
Exhalation valve
19
Thermistor assy
5
Exhalation pressure transducer autozero solenoid
Cylinder pressure transducer autozero solenoid
4
15
Exhalation flow sensor
①
②
16
Expiratory filter
Inspiratory filter
Collector vial
To patient
7-00019

Figure 9-23. Tubing

9.22 Harnesses and wiring

Harnesses and wiring parts list

Item no. (Figure 9-24)	Part no.	Quantity	Description
1	G-060104-00	1	Harness, ventilator head, main
2	G-060100-00	1	Cable assembly, UI/ventilator head
3	G-060846-00	1	Harness, BBU PCB/ventilator head
4	G-060514-00	1	Wire, ground, UI
5	G-060113-00	1	Harness, external battery
6	G-060117-00	1	Harness, power supply/BBU PCB
7	G-060110-00	1	Harness, circuit breaker/power switch
8	G-060111-00	1	Harness, power switch/power supply
9	G-060830-00	1	Wire, ground, power input terminal
10	G-060829-00	1	Harness, internal battery
11	G-061086-00	1	Wire, ground, line filter
12	G-060110-00	1	Harness, line filter/circuit breaker
13	G-060116-00	1	Harness, power switch/BBU PCB

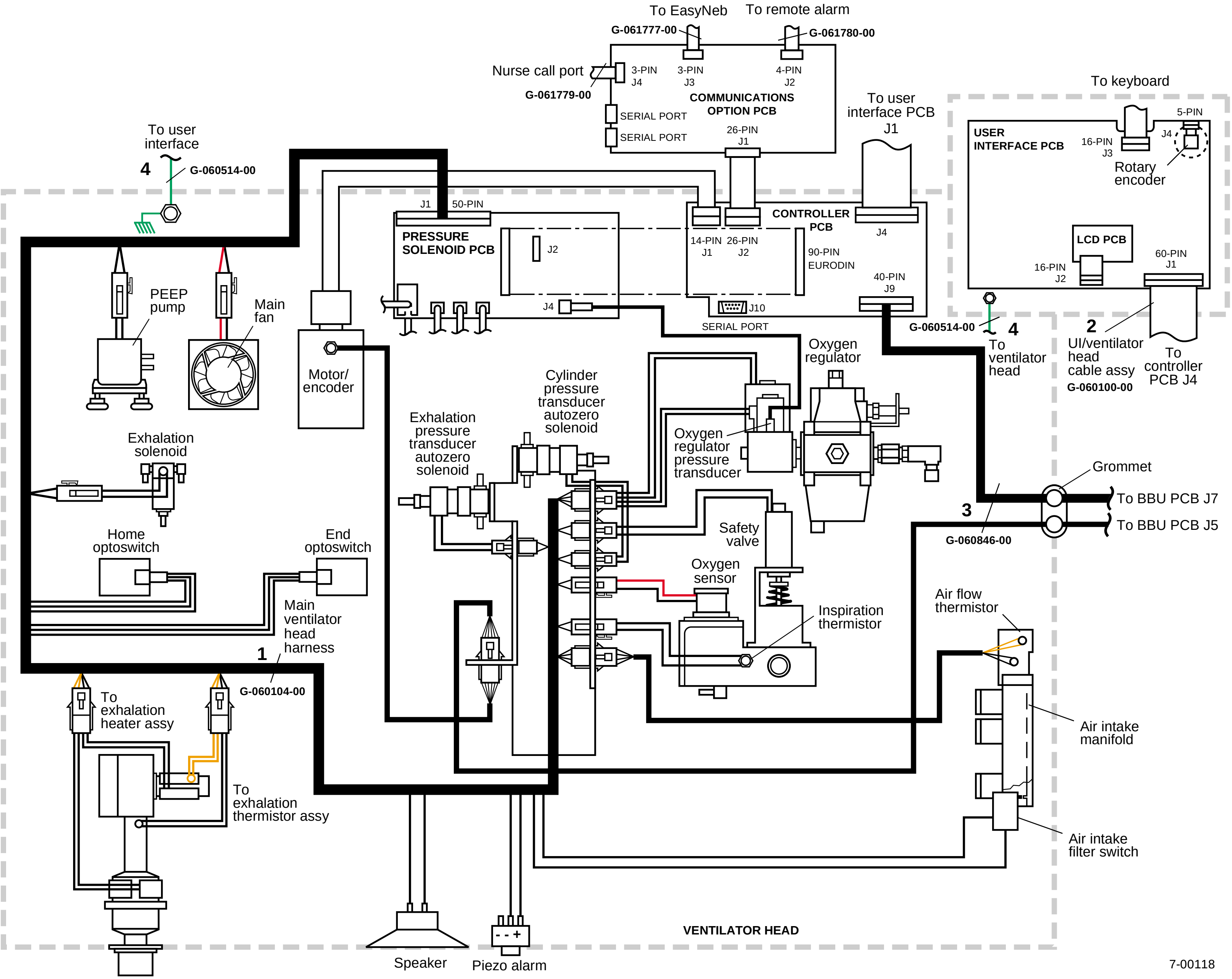

To EasyNeb
To remote alarm
G-061777-00
G-061780-00
Nurse call port
G-061779-00
3-PIN
J4
3-PIN
J3
4-PIN
J2
COMMUNICATIONS
OPTION PCB
SERIAL PORT
SERIAL PORT
26-PIN
J1
To user
interface PCB
J1
To keyboard
USER
INTERFACE PCB
16-PIN
J3
J4
5-PIN
Rotary
encoder
LCD PCB
16-PIN
J2
60-PIN
J1
To user
interface
4
G-060514-00
J1
50-PIN
PRESSURE
SOLENOID PCB
J2
J4
CONTROLLER
PCB
14-PIN
J1
26-PIN
J2
J4
90-PIN
EURODIN
40-PIN
J9
J10
SERIAL PORT
G-060514-00
4
To
ventilator
head
2
UI/ventilator
head
cable assy
G-060100-00
To
controller
PCB J4
PEEP
pump
Main
fan
Motor/
encoder
Oxygen
regulator
Cylinder
pressure
transducer
autozero
solenoid
Exhalation
pressure
transducer
autozero
solenoid
Oxygen
regulator
pressure
transducer
Exhalation
solenoid
Grommet
To BBU PCB J7
To BBU PCB J5
3
G-060846-00
Safety
valve
Home
optoswitch
End
optoswitch
Oxygen
sensor
Main
ventilator
head
harness
Inspiration
thermistor
Air flow
thermistor
1
G-060104-00
To
exhalation
heater assy
To
exhalation
thermistor assy
Air intake
manifold
Air intake
filter switch
VENTILATOR HEAD
Speaker
Piezo alarm
- - +
7-00118

Figure 9-24. Wiring diagram (Sheet 1 of 2)

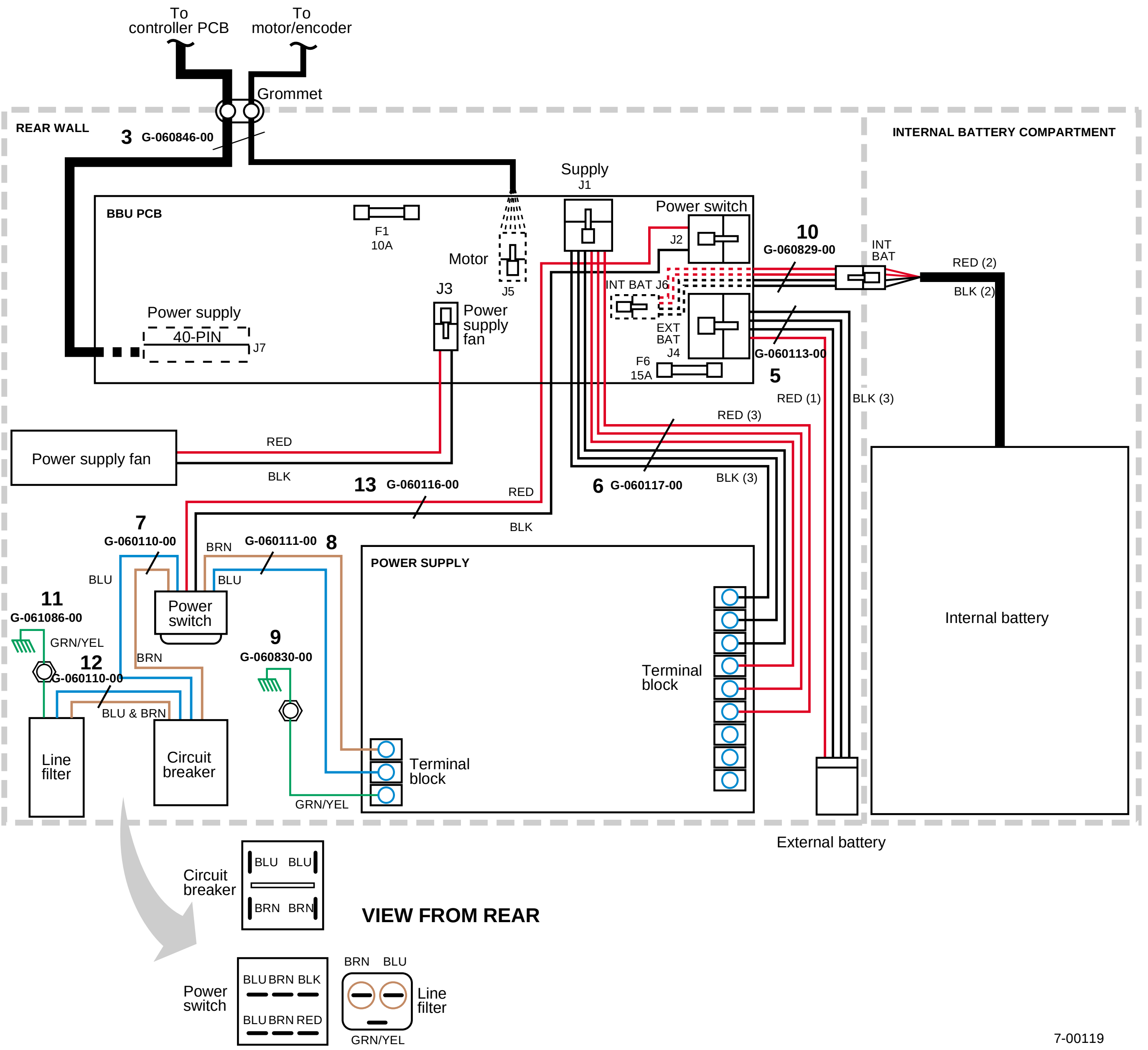

To
controller PCB
To
motor/encoder
Grommet
REAR WALL
3 G-060846-00
INTERNAL BATTERY COMPARTMENT
BBU PCB
F1
10A
Supply
J1
Power switch
J2
10
G-060829-00
INT
BAT
RED (2)
BLK (2)
Motor
J5
J3
Power
supply
fan
INT BAT J6
EXT
BAT
J4
F6
15A
G-060113-00
5
RED (1)
BLK (3)
Power supply
40-PIN
J7
RED (3)
Power supply fan
RED
BLK
13 G-060116-00
RED
6 G-060117-00
BLK (3)
BLK
7
G-060110-00
BRN
G-060111-00 8
BLU
BLU
POWER SUPPLY
11
G-061086-00
Power
switch
GRN/YEL
12
G-060110-00
BRN
9
G-060830-00
Terminal
block
Internal battery
BLU & BRN
Line
filter
Circuit
breaker
Terminal
block
GRN/YEL
External battery
Circuit
breaker
BLU BLU
BRN BRN
VIEW FROM REAR
Power
switch
BLU BRN BLK
BLU BRN RED
BRN BLU
Line
filter
GRN/YEL
7-00119

Figure 9-24. Wiring diagram (Sheet 2 of 2)

9.23 15,000-hour preventive maintenance kit

15,000-hour preventive maintenance kit parts list

Item no. (Figure 9-25)	Part no.	Quantity	Description
--	G-061166-00	--	Kit, preventive maintenance, 15,000-hour
1	--	1	• Filter, fan
2	G-060129-00	1	• Fan, main
3	G-060131-00	1	• Fan, power supply
4	G-060090-00	1	• Solenoid, exhalation
5	G-062022-00	1	• Regulator, oxygen
6	G-060532-00	1	• Grease, 10 grams (not shown)
7	--	1	• Label, preventive maintenance, 15,000-hour (not shown)
8	G-062301-00	1	• Grommet kit, inspiration access panel (includes 10 grommets) (not shown)

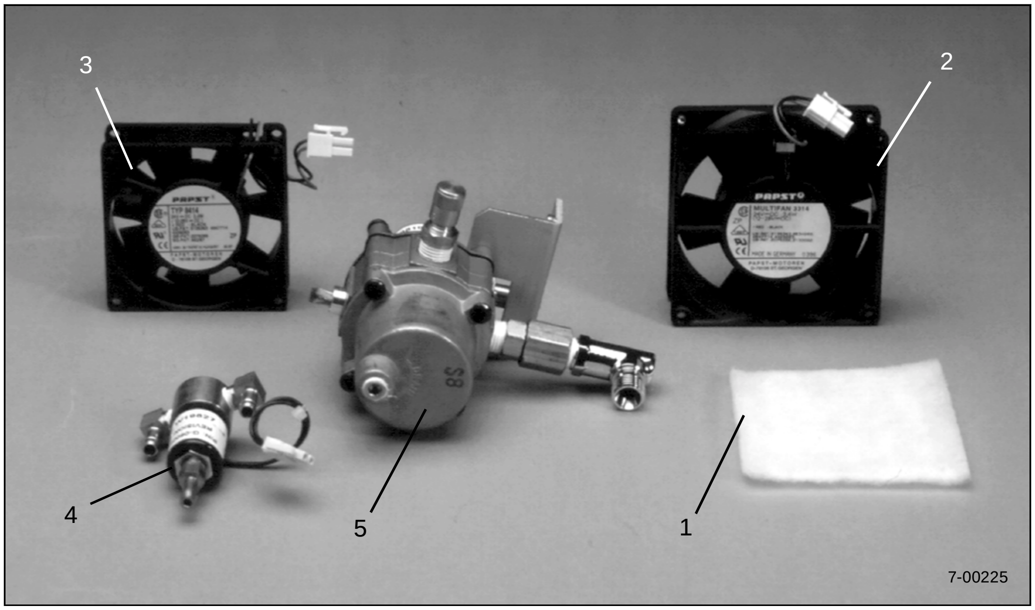


Figure 9-25. 15,000-hour preventive maintenance kit

9.24 30,000-hour preventive maintenance kit

30,000-hour preventive maintenance kit parts list

Item no. (Figure 9-26)	Part no.	Quantity	Description
--	G-061167-00	--	Kit, preventive maintenance, 30,000-hour
1	--	1	• Filter, fan
2	G-060129-00	1	• Fan, main
3	G-060131-00	1	• Fan, power supply
4	G-060090-00	1	• Solenoid, exhalation
5	G-062022-00	1	• Regulator, oxygen
6	G-060532-00	1	• Grease, 10 grams (not shown)
7	G-061133-00	1	• Pump, vibrating armature (PEEP)
8	--	1	• Label, preventive maintenance, 30,000-hour (not shown)
9	G-062301-00	1	• Grommet kit, inspiration access panel (includes 10 grommets) (not shown)

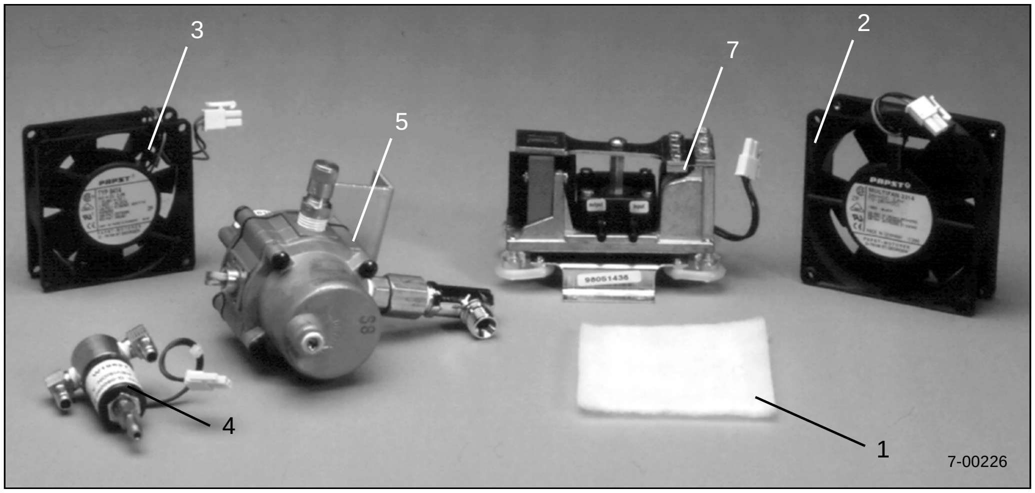


Figure 9-26. 30,000-hour preventive maintenance kit

9.25 *700 Series* Ventilator spare parts kit

***700 Series* Ventilator spare parts kit parts list**

Item no.	Part no.	Quantity	Description
--	G-061560-00	--	Kit, *700 Series* Ventilator service (spare parts)
1	G-061129-00	1	• PCB, battery backup (BBU)
2	G-062146-00	1	• PCB, controller
3	G-061252-00	1	• Check valve, exhalation
4	G-061693-00	1	• Heater assembly, exhalation
5	G-061526-00	1	• Valve assembly, exhalation
6	G-061144-00	1	• Flow sensor assembly
7	G-061139-00	1	• Battery, internal
8	G-061138-00	1	• Motor/encoder assembly
9	G-061255-00	1	• Optoswitch (motor-opto) assembly
10	G-062022-00	1	• Regulator, oxygen
11	G-061133-00	1	• Pump, vibrating armature (PEEP)
12	--	--	• Not used
13	G-061127-00	1	• PCB, pressure solenoid
14	--	--	• Not used
15	G-061262-00	1	• Filter, air intake (package of 6)
16	G-060033-00	1	• Circuit breaker
17	G-060090-00	1	• Solenoid, exhalation (PEEP)
18	G-060129-00	1	• Fan, main
19	G-061263-00	1	• Filter, fan (package of 6)
20	G-060131-00	1	• Fan, power supply
21	G-060293-00	1	• Fuse, 10 A, fast-blow, F-type (F1)
22	G-060292-00	1	• Fuse, 15 A, standard, T-type (F6)
23	G-060045-00	1	• Gasket, check valve
24	G-062138-00	1	• Alarm, piezo (buzzer)
25	G-061085-00	1	• Line filter
26	G-060031-00	1	• Switch, power
27	G-061694-00	1	• Transducer, pressure, oxygen regulator
28	G-060771-00	1	• Rotary encoder, UI

Parts listed here are shown in other figures throughout the manual.

700 Series Ventilator spare parts kit parts list (continued)

Item no.	Part no.	Quantity	Description
29	G-061407-00	1	• Tube kit, silicone, 3-mm ID x 6-mm OD, 65.5 cm (Can be cut to supply one each of the following 3-mm ID x 6-mm OD tubes) (G-060125-00)
30	G-061408-00	1	• Tube kit, silicone, 3/16-in. ID x 3/8-in. OD, 89.0 cm (Can be cut to supply one each of the following 3/16-in. ID x 3/8-in. OD tubes) (4-008575-00)
31	G-061406-00	1	• Tube kit, silicone, 3/4-in. ID x 1-in. OD, 45.2 cm (Can be cut to supply one each of the following 3/4-in. ID x 1-in. OD tubes) (G-060495-00)
32	G-060767-00	1	• Tube, silicone, 3/4-in. ID x 1-in. OD, elbow
33	G-060845-00	1	• Thermistor assembly, air flow
34	G-060095-00	1	• Thermistor, inspiration manifold
35	G-061556-00	1	• Fuse, 15 A, 32 V, blade (external battery)
36	G-061251-00	1	• Check valve, cylinder inlet (white housing)
37	G-061250-00	1	• Check valve, cylinder outlet (blue housing)
38	G-062023-00	1	• Oxygen solenoid assembly
Parts listed here are shown in other figures throughout the manual.			

9.26 Service tool kit

700 Series **Ventilator service tool kit**

Item no.	Part no.	Quantity	Description
--	G-061561-00	--	Kit, *700 Series* Ventilator service tool
1	G-061566-00	1	• NVRAM extractor tool
2	G-061914-00	1	• EPROM extractor tool, 32-pin, PLCC type
3	G-061567-00	1	• Multimeter patch cord set, 0.025 square receptacle (Includes red cord (P/N G-061579-00) and black cord (P/N G-061580-00))
4	G-061661-00	1	• Kit, static-dissipative field service (includes wrist strap, static-dissipative mat, and ground cord)
5	G-061574-00	1	• Stopper, wye (no. 2)
6	G-061575-00	1	• Stopper, inspiration port (no. 3)
7	G-061208-00	1	• Ventilator breathing circuit, adult, reusable, without heated wire (for use as test circuit)
8	G-061573-00	1	• Kit, tubing, performance verification. Includes: • • two couplings (P/N 4-003443-00) • • two tube junction connectors (P/N 4-011521-00) • • 30-cm, 3/16-in. ID x 3/8-in. OD tubing
9	4-000612-00	1	• Test lung with strap
10	G-061540-00	1	• PEEP pump calibration tool
11	G-061557-00	1	• Kit, P_eP_{cyl} gain equalization. Includes: • • 5-mL syringe (P/N G-061558-00) • • reservoir (P/N 4-011413-00) • • tee (4-003891-00) • • four 25-cm lengths, 3-mm ID x 6-mm OD tubing
12	G-060759-00	1	• Tape, PTFE
13	G-060532-00	1	• Grease, 10 grams
14	G-061576-00	1	• Cleaning spray, UI
15	G-061568-00	1	• Brush, rack grease
16	G-061534-00	1	• Bag, electrostatic-shielding, 66 x 46 cm (26 x 18 in.)
17	G-061532-00	1	• Bag, electrostatic-shielding, 13 x 20 cm (5 x 8 in.)
18	G-061533-00	1	• Bag, electrostatic-shielding, 28 x 38 cm (11 x 15 in.)
19	G-061660-00	10	• Label, antistatic

9.27 Oxygen sensor assemblies

700 Series Ventilator oxygen sensor assemblies

Item no.	Part no.	Quantity	Description
1	G-062022-00	1	• Regulator, oxygen
2	G-062023-00	1	• Oxygen solenoid assembly
3	G-062009-00	1	• Oxygen sensor kit (includes oxygen sensor, sensor harness, adapter, and hardware; replaces sensor with integral harness)
4	G-062010-00	1	• Oxygen sensor (includes oxygen sensor only)
Parts listed here are shown in other figures throughout the manual.			

9.28 Communications option

700 Series Communications option assemblies

Item no.	Part no.	Quantity	Description
--	G-061831-00	--	Kit, Communications option upgrade
1	G-062013-00	1	Plate assembly, Communications option
2	G-062015-00	1	PCB assembly, Communications option
3	G-062014-00	1	Harness, nebulizer
4	G-062016-00	1	Harness, remote alarm
5	G-062017-00	1	Harness, communications (ribbon cable to/from controller PCB)
6	G-062018-00	1	Hardware, RS-232
7	G-062003-00	1	Harness, nurse call (central station)

9.29 *760* Ventilator assemblies

***760* Ventilator assemblies**

Item no.	Part no.	Quantity	Description
1	G-062146-00	1	PCB, controller
2	G-062030-00	1	Kit, upgrade, *740*-to-*760* Ventilator, English
	G-062153-00	1	Kit, upgrade, *740*-to-*760* Ventilator, French
	G-062154-00	1	Kit, upgrade, *740*-to-*760* Ventilator, German
	G-062155-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Italian
	G-062156-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Spanish
	G-062157-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Portuguese
	G-062158-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Polish
	G-062159-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Russian
	G-062160-00	1	Kit, upgrade, *740*-to-*760* Ventilator, Japanese

SECTION

A

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Description	Part no.	Figure no.	Item no.
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Hose assembly, oxygen, Dräger	5-029059-00	Figure 9-2	6
Hose assembly, oxygen, for Australia	G-061197-00	Figure 9-2	4
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Description	Part no.	Figure no.	Item no.
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Kit, P_eP_{cyl} gain equalization	G-061557-00	Section 9.26	11
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Kit, *700 Series* Ventilator service tool	G-061561-00	Section 9.26	--
Kit, *700 Series* Ventilator service (spare parts)	G-061560-00	Section 9.25	--
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Label, main fan filter	--	Figure 9-10	2
Label, on/off switch	--	Figure 9-10	8
Label, oxygen inlet port	--	Figure 9-10	1
Label, patient circuit expiratory port	--	Figure 9-10	5
Label, patient circuit inspiratory port	--	Figure 9-10	6
Label, power switch	--	Figure 9-20	59
Label kit, English, *740* Ventilator	G-061388-00	Figure 9-8	20
		Figure 9-10	0
Label kit, French, *740* Ventilator	G-061390-00	Figure 9-8	20
		Figure 9-10	0
Label kit, German, *740* Ventilator	G-061389-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Italian, *740* Ventilator	G-061391-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Japanese, *740* Ventilator	G-061395-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Polish, *740* Ventilator	G-061394-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Portuguese, *740* Ventilator	G-061393-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Russian, *740* Ventilator	G-061396-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Spanish, *740* Ventilator	G-061392-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Dutch, *760* Ventilator	G-062172-00	Figure 9-8	20
		Figure 9-10	0
Label kit, English, *760* Ventilator	G-062164-00	Figure 9-8	20
		Figure 9-10	0
Label kit, French, *760* Ventilator	G-062165-00	Figure 9-8	20
		Figure 9-10	0
Label kit, German, *760* Ventilator	G-062160-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Italian, *760* Ventilator	G-062167-00	Figure 9-8	20
		Figure 9-10	0

Description	Part no.	Figure no.	Item no.
Label kit, Japanese, *760* Ventilator	G-062171-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Polish, *760* Ventilator	G-062169-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Portuguese, *760* Ventilator	G-062189-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Russian, *760* Ventilator	G-062170-00	Figure 9-8	20
		Figure 9-10	0
Label kit, Spanish, *760* Ventilator	G-062168-00	Figure 9-8	20
		Figure 9-10	0
Latch lock bracket	--	Figure 9-4	12
Latch retaining bracket kit	G-062375-00	Figure 9-4	12
LCD panel, English/Japanese	G-061142-00	Figure 9-7	20
LCD panel, European	G-061430-00	Figure 9-7	20
LCD panel, Russian/Polish	G-061793-00	Figure 9-7	20
Lid	--	Figure 9-7	2
Lid assembly	G-061427-00	Figure 9-7	1
Line filter	G-061085-00	Figure 9-20	9
		Section 9.19	25
Manifold assembly, air intake (replaces previous, P/N G-060217-00)	G-062026-00	Figure 9-8	26
		Section 9.9	1
Manifold assembly, mixing	G-062293-00	Figure 9-12	5
Mixing manifold kit	G-062293-00	--	--
Motor/encoder assembly	G-061138-00	Figure 9-18	12
		Section 9.17	8
Mounting block, flex arm	G-060121-00	Figure 9-8	21
Mounting kit, collector vial, cart-mount	G-061124-00	Figure 9-5	16
Mounting kit, Fisher & Paykel humidifier, cart	G-061227-00	Figure 9-5	31
Mounting kit, Fisher & Paykel humidifier, shelf	G-061602-00	Figure 9-6	20
Mounting kit, Hudson RCI ConchaTherm 3 humidifier, cart	G-061228-00	Figure 9-5	37
Mounting kit, oxygen cylinder	G-061280-00	Figure 9-5	8
Mounting kit, shelf, for use with Fisher & Paykel humidifiers	G-061279-00	Figure 9-4	17
		Figure 9-6	0
Mounting kit, shelf, for use with Hudson RCI ConchaTherm 3 humidifier	G-061601-00	Figure 9-6	0
Multimeter patch cord set, 0.025 square receptacle	G-061567-00	Section 9.26	3
Nut, HEX (Attaches rotary encoder)	--	Figure 9-7	14
Nut, HEX, M2.5 (Attaches LCD panel)	G-060988-00	Figure 9-7	23
Nut, HEX, M3 (Attaches BBU PCB)	G-060989-00	Figure 9-20	30
Nut, HEX, M4 (Attaches bottom of cable management bar)	G-060990-00	Figure 9-14	2
Nut, HEX, M4 (Attaches keyboard to PCB)		Figure 9-7	7
Nut, HEX, M4 (Attaches line filter ground wire)		Figure 9-20	40
Nut, HEX, M4 (Attaches PEEP pump)		Figure 9-17	2
Nut, HEX, M4 (Attaches power input terminal ground wire)		Figure 9-20	54

Description	Part no.	Figure no.	Item no.
Nut, HEX, M5 (Attaches ground wire)	G-060991-00	Figure 9-4	4
Nut, HEX, M5 (Attaches Hudson support bracket to cart interface bracket)		Figure 9-5	42
Nut, HEX, M6 (Attaches assembled ventilator/mount to shelf)	--	Figure 9-6	16
Nut, HEX, with washer, EX LK, M3 (Attaches expiratory filter housing to cabinet)	G-061055-00	Figure 9-13	20
Nut, HEX, with washer, EX LK, M3 (Attaches tension clip)		Figure 9-7	5
Nut, HEX, with washer, EX LK, M3 (Attaches UI to lid)		Figure 9-7	11
Nut, HEX, with washer, EX LK, M4 (Attaches cylinder cover or cylinder support to cart)	--	Figure 9-5	7
Nut, HEX, with washer, EX LK, M6 (Attaches cylinder bracket to cart)	--	Figure 9-5	15
NVRAM (nonvolatile RAM) (U6)	G-061686-00	Figure 9-14	15
NVRAM extractor tool	G-061566-00	Section 9.26	1
O-ring, exhalation valve	G-060823-00	Figure 9-13	3
O-ring, oxygen hose, Air Liquide (for France)	--	Figure 9-9	4
Optoswitch (motor-opto) assembly	G-061255-00	Figure 9-18	16
		Section 9.17	9
Oxygen regulator assembly	--	Figure 9-8	36
Oxygen regulator pressure transducer (Po) calibration tool	G-061541-00	Section 4.2.3.2.2	--
Oxygen sensor (includes oxygen sensor only)	G-062010-00	Figure 9-11	2
		Section 9.27	4
Oxygen sensor kit (includes oxygen sensor, sensor harness, adapter, and hardware; replaces sensor with integral harness)	G-062009-00	Figure 9-11	2
		Section 9.27	3
Oxygen solenoid assembly	G-062023-00	Figure 9-12	3
		Section 9.25	38
		Section 9.27	2
		Section 9.13	3
PCB assembly, Communicatons option	G-062015-00	Section 9.28	2
PCB, battery backup (BBU)	G-061129-00	Figure 9-20	25
		Section 9.25	1
PCB, controller	G-062146-00	Figure 9-14	14
		Section 9.25	2
		Section 9.29	1
PCB, pressure solenoid	G-061127-00	Figure 9-14	16
		Section 9.25	13
PCB, *740* UI display	G-061130-00	Figure 9-7	6
PCB, *760* UI display	G-062227-00	Figure 9-7	6
PEEP pump and reservoir	--	Figure 9-8	39
PEEP pump calibration tool	G-061540-00	Section 9.26	10
Piston/cylinder assembly	G-061134-00	Figure 9-18	1
Plate assembly, Communications option	G-062013-00	Section 9.28	1

Description	Part no.	Figure no.	Item no.
Plate, battery compartment access	G-060448-00	Figure 9-8	5
		Figure 9-19	15
Plate, inspiratory access panel, Dutch	G-062312-00	Figure 9-8	4
Plate, inspiratory access panel, English	G-062303-00	Figure 9-8	4
Plate, inspiratory access panel, French	G-062304-00	Figure 9-8	4
Plate, inspiratory access panel, German	G-062305-00	Figure 9-8	4
Plate, inspiratory access panel, Italian	G-062306-00	Figure 9-8	4
Plate, inspiratory access panel, Japanese	G-062311-00	Figure 9-8	4
Plate, inspiratory access panel, Polish	G-062309-00	Figure 9-8	4
Plate, inspiratory access panel, Portuguese	G-062308-00	Figure 9-8	4
Plate, inspiratory access panel, Russian	G-062310-00	Figure 9-8	4
Plate, inspiratory access panel, Spanish	G-062307-00	Figure 9-8	4
Plate, options panel	G-060450-00	Figure 9-8	3
Plate, serial number	--	Figure 9-8	46
Plate, shelf mounting	G-061154-00	Figure 9-6	2
Post, HEX, mini-support (Attaches controller PCB)	G-060934-00	Figure 9-14	17
Power assembly	--	Figure 9-19	2
		Figure 9-20	0
Power cord	--	Figure 9-20	39
Power cord, for Australia	G-061242-00	Figure 9-22	2
Power cord, for continental Europe	G-061243-00	Figure 9-22	3
Power cord, for Denmark	G-061244-00	Figure 9-22	9
Power cord, for India/South Africa (old, British-style plug with round prongs)	G-061247-00	Figure 9-22	4
Power cord, for Israel	G-061248-00	Figure 9-22	5
Power cord, for Italy	G-061245-00	Figure 9-22	6
Power cord, for North America/Japan	G-061241-00	Figure 9-22	1
Power cord, for Switzerland	G-061246-00	Figure 9-22	7
Power cord, for United Kingdom	G-060135-00	Figure 9-22	8
Power cord retainer kit	G-061942-00	Figure 9-19	11
		Figure 9-20	11
Power supply, 120/230 V, *740/760* Ventilators (230 V regions, all languges)	G-061131-00	Figure 9-20	5
Power supply, 120 V, *740/760* Ventilators (120 V regions, English)	G-062334-00	Figure 9-20	5
Power supply, 120 V, *740/760* Ventilators (120 V regions, Spanish)	G-062336-00	Figure 9-20	5
Power supply, 120 V, *740/760* Ventilators (120 V regions, French)	G-062344-00	Figure 9-20	5
Power supply, 120 V, *740/760* Ventilators (120 V regions, Japanese)	G-062346-00	Figure 9-20	5
Power supply, 120 V, *740/760* Ventilators (120 V regions, Portuguese)	G-062348-00	Figure 9-20	5
Power tray	G-060444-00	Figure 9-20	14
Pump. *See also* Piston/cylinder assembly			
Pump, vibrating armature (PEEP)	G-061133-00	Figure 9-17	1
		Figure 9-26	7
		Section 9.25	11

Description	Part no.	Figure no.	Item no.
Regulator, oxygen	G-062022-00	Figure 9-12	1
		Figure 9-25	5
		Figure 9-26	5
		Section 9.25	10
		Section 9.27	1
Reservoir	--	Figure 9-17	5
Reservoir assembly, PEEP	G-061431-00	Figure 9-17	4
Rivet (Attaches power cord retainer)	G-061182-00	Figure 9-20	15
Rivet (Attaches serial number plate)		Figure 9-8	7
Rotary encoder, UI	G-060771-00	Figure 9-7	15
		Section 9.25	28
Safety valve assembly	G-061257-00	Figure 9-11	3
Screw, FH, M3 x 8, POZIDRIV (Retains BBU PCB grommet bracket)	G-060986-00	Figure 9-20	52
Screw, FH, M3 x 8, POZIDRIV (Attaches external battery harness)		Figure 9-20	2
Screw, FH, M3 x 8, POZIDRIV (Attaches line filter)		Figure 9-20	10
Screw, FH, M3 x 8, POZIDRIV (Attaches power supply fan bracket to base)		Figure 9-20	20
Screw, FH, M3 x 12, POZIDRIV (Attaches FET heat bars)	G-061024-00	Figure 9-20	33
Screw, FH, M3 x 12, POZIDRIV (Attaches miniFET heat bar)		Figure 9-20	36
Screw, FH, M4 x 6, POZIDRIV (Attaches power supply from bottom)	G-060987-00	Figure 9-20	6
Screw, FH, M5 x 10 (Attaches Fisher & Paykel humidifier support bracket to plate)	G-061476-00	Figure 9-6	22
Screw, FH, M5 x 20, POZIDRIV (Attaches Hudson RCI ConchaTherm 3 humidifier support bracket to plate)	G-061650-00	Figure 9-6	24
Screw, FH, M5 x 25, POZIDRIV (Attaches support bracket to cart interface bracket)	G-061647-00	Figure 9-5	40
Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches air intake filter assembly)	G-061122-00	Figure 9-8	29
Screw, PAN, M3 x 8, POZIDRIV, with captive washers (Attaches fan/fan guard to ventilator)		Figure 9-19	10
Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches flow sensor assembly and expiratory filter housing to cabinet)		Figure 9-13	17
Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches inspiratory access panel plate)		Figure 9-8	11
Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches options panel plate)		Figure 9-8	8
Screw, PAN, M3 x 8, POZIDRIV, with washers (Attaches power cord retainer)		Figure 9-20	12
Screw, PAN, M3 x 12, POZIDRIV, with washers (Attaches battery compartment access plate)	G-061094-00	Figure 9-8	14
		Figure 9-19	16
Screw, PAN, M3 x 12, POZIDRIV, with captive washers (Attaches power assembly)		Figure 9-19	3
Screw, PAN, M3 x 12, POZIDRIV, with captive washers (Attaches speaker)		Figure 9-14	10
Screw, PAN, M3 x 14, POZIDRIV (Attaches air intake filter switch to manifold)	G-061622-00	Figure 9-8	52

Description	Part no.	Figure no.	Item no.
Screw, PAN, M4 x 12, Phillips (Attaches ball bracket to cart)	--	Figure 9-5	24
Screw, PAN, M5 x 16, POZIDRIV (Attaches mounting block)	G-061091-00	Figure 9-8	22
Screw, PAN, M6 x 20, POZIDRIV (Attaches Hudson humidifier bracket assembly to cart)	G-061648-00	Figure 9-5	43
Screw, SOC, 6-32 x 5/16 (Attaches autozero solenoids)	G-061203-00	Figure 9-14	7
Screw, SOC, M3 x 6 (Attaches BBU PCB)	G-061027-00	Figure 9-20	28
Screw, SOC, M3 x 8 (Attaches air flow thermistor assembly)	G-060976-00	Figure 9-8	33
Screw, SOC, M3 x 8 (Attaches cable tie that retains main ventilator head harness)		Figure 9-8	47
Screw, SOC, M3 x 8 (Attaches exhalation valve to flow sensor; attaches exhalation valve to cross tube; attaches check valve to expiratory filter housing)		Figure 9-13	4
Screw, SOC, M3 x 8 (Attaches optoswitch)		Figure 9-18	17
Screw, SOC, M3 x 8 (Attaches power supply fan to bracket)		Figure 9-20	22
Screw, SOC, M3 x 8 (Attaches safety valve)		Figure 9-11	5
Screw, SOC, M3 x10 (Attaches fan to fan guard)	G-061031-00	Figure 9-19	12
Screw, SOC, M3 x 10 (Attaches inspiration manifold)		Figure 9-11	8
Screw, SOC, M3 x 10 (Attaches mixing manifold)		Figure 9-12	6
Screw, SOC, M3 x 10 (Attaches oxygen sensor holder to inspiration manifold)		Figure 9-11	12
Screw, SOC, M3 x 12 (Attaches rack cover to piston/cylinder)	G-060977-00	Figure 9-18	7
Screw, SOC, M4 x 8 (Attaches collector vial support bracket to cart)	G-060978-00	Figure 9-5	18
Screw, SOC, M4 x 8 (Attaches PEEP reservoir)		Figure 9-17	10
Screw, SOC, M4 x 8 (Attaches top of cable management bar)		Figure 9-14	4
Screw, SOC, M4 x 10 (Attaches collector vial bracket to plate)	G-061477-00	Figure 9-6	7
Screw, SOC, M4 x 12 (Attaches baffle to power supply)	G-060979-00	Figure 9-20	44
Screw, SOC, M4 x 12 (Attaches power supply to back panel)		Figure 9-20	3
Screw, SOC, M4 x 12 (Retains check valve)		Figure 9-13	8
Screw, SOC, M4 x 12 (Secures bottom of lid)		Figure 9-4	12
Screw, SOC, M4 x 14 (Attaches exhalation solenoid)	G-061149-00	Figure 9-17	13
Screw, SOC, M5 x 8 (Attaches ventilator to shelf mount)	G-060980-00	Figure 9-6	10
Screw, SOC, M5 x 10 (Attaches plate to bracket)	--	Figure 9-6	3
Screw, SOC, M5 x 12 (Attaches exhalation assembly cover)	G-061202-00	Figure 9-13	22
Screw, SOC, M5 x 12 (Attaches Fisher & Paykel humidifier support bracket to cart)		Figure 9-5	33
Screw, SOC, M5 x 12, POZIDRIV (Attaches piston/cylinder to cabinet)		Figure 9-18	9
Screw, SOC, M5 x 20 (Attaches motor/encoder)	G-061039-00	Figure 9-18	13
Screw, SOC, M6 x 16 (Attaches column to base)	--	Figure 9-5	3
Screw, SOC, M6 x 16 (Attaches cylinder bracket to cart)		Figure 9-5	12
Screw, SOC, M6 x 16 (Attaches ventilator to cart)		Figure 9-5	27
Screw, SOC, M6 x 16 (Attaches ventilator to cart)		Figure 9-4	9
Screw, SOC, M6 x 30 (Attaches assembled ventilator/mount to shelf)	--	Figure 9-6	13
Screw, wing, M10 (Attaches cylinder bracket to cylinder)	--	Figure 9-5	11

Description	Part no.	Figure no.	Item no.
Seal, UI	G-060128-00	Figure 9-7	19
Seat, safety valve	G-060072-00	Figure 9-11	4
Shaft, rotating	--	Figure 9-3	9
Shaft with pivot, 0.34 m (13.55 in.) long	--	Figure 9-3	7
Shaft with pivot, 0.38 m (15.0 in.) long	--	Figure 9-3	8
Shoulder bolt, M4 (attaches oxygen regulator bracket to inspiration access panel plate) (order grommet and shoulder bolt kit P/N G-062297-00)	--	Figure 9-8	17
Solenoid, autozero (cylinder pressure transducer/exhalation pressure transducer)	G-060098-00	Figure 9-14	6
Solenoid, exhalation (PEEP)	G-060090-00	Figure 9-17	12
		Figure 9-25	4
		Figure 9-26	4
		Section 9.25	17
Spacer, M2.5, nylon, UI message window (Attaches LCD panel)	G-060907-00	Figure 9-7	21
Spacer, M4, nylon, UI subpanel (Attaches keyboard to PCB)	G-060905-00	Figure 9-7	9
Spacer, nylon, UI encoder (Attaches rotary encoder)	G-060906-00	Figure 9-7	16
Speaker	G-060496-00	Figure 9-14	9
Standoff, M3 (attaches pressure solenoid PCB)	G-061677-00	Figure 9-14	20
Standoff, male-female, M3 x 6 (Separates BBU PCB from power tray)	G-060535-00	Figure 9-20	34
Standoff, male-female, M3 x 17 (Attaches pressure solenoid PCB)	G-061410-00	Figure 9-14	19
Standoff, male-male, M3 x 10 (Attaches controller PCB)	G-060505-00	Figure 9-14	18
Stopper, inspiration port (no. 3)	G-061575-00	Section 9.26	6
Stopper, wye (no. 2)	G-061574-00	Section 9.26	5
Strip, thermal conductive	G-060937-00	Figure 9-20	49
Support, oxygen cylinder (lower)	--	Figure 9-5	9
Support bracket, Fisher & Paykel humidifiers	--	Figure 9-5	32
		Figure 9-6	21
Switch, air intake filter	G-061572-00	Figure 9-8	51
Switch, power	G-060031-00	Figure 9-20	7
		Section 9.25	26
Tape, PTFE (part of *700 Series* Ventilator service tool kit)	G-060759-00	Section 9.26	12
Tape, PTFE (Used on threads of oxygen adapters)		Figure 9-9	10
Tape, PTFE (Used on threads of oxygen fitting)		Figure 9-8	44
Tape, PTFE (Used on threads of oxygen fitting, oxygen regulator pressure transducer, and oxygen regulator extension)		Figure 9-12	9
Test lung with strap	4-000612-00	Section 9.26	9
Thermistor, inspiration manifold	G-060095-00	Figure 9-11	7
		Section 9.25	34
Thermistor assembly, air flow	G-060845-00	Figure 9-8	32
		Section 9.25	33
Thermistor assembly, exhalation	G-060844-00	Figure 9-13	15

Description	Part no.	Figure no.	Item no.
Tie wrap, air intake (Attaches BBU PCB/ventilator head harness to upper righthand screw at rear of air intake housing)	G-061088-00	Figure 9-8	50
Transducer, pressure, oxygen regulator	G-061694-00	Figure 9-12	8
		Section 9.25	27
Tube, adult, 15-cm (Connects collector vial to expiratory filter)	G-061441-00	Figure 9-1	7
Tube, silicone, 1/8-in. ID x 1/4-in. OD	--	Figure 9-23	18
		Figure 9-23	19
		Figure 9-23	20
Tube, silicone, 3-mm ID x 6-mm OD	--	Figure 9-23	2
		Figure 9-23	3
		Figure 9-23	4
		Figure 9-23	5
Tube, silicone, 3-mm ID x 6-mm OD, 16.0-cm	--	Figure 9-17	6
Tube, silicone, 3/16-in. ID x 3/8-in. OD	--	Figure 9-17	8
		Figure 9-23	7
		Figure 9-23	8
		Figure 9-23	9
		Figure 9-23	10
Tube, silicone, 3/16-in. ID x 3/8-in. OD, 13.0-cm	--	Figure 9-17	7
Tube, silicone, 3/4-in. ID x 1-in. OD	--	Figure 9-12	4
		Figure 9-18	19
		Figure 9-23	12
		Figure 9-23	13
		Figure 9-23	14
Tube, silicone, 3/4-in. ID x 1-in. OD, elbow	G-060767-00	Figure 9-23	15
		Section 9.25	32
Tube assembly, flow sensor	G-061087-00	Figure 9-13	25
		Figure 9-23	16
Tube kit, silicone, 1/8-in. ID x 1/4-in. OD, 49.5 cm	G-061455-00	Figure 9-23	17
Tube kit, silicone, 3-mm ID x 6-mm OD, 65.5 cm	G-061407-00	Figure 9-23	1
		Section 9.25	29
Tube kit, silicone, 3/16-in. ID x 3/8-in. OD, 89.0 cm	G-061408-00	Figure 9-23	6
		Section 9.25	30
Tube kit, silicone, 3/4-in. ID x 1-in. OD, 45.2 cm	G-061406-00	Figure 9-23	11
		Section 9.25	31
User interface (UI) assembly	--	Figure 9-4	2
		Figure 9-7	0
Valve, exhalation	--	Figure 9-13	2
Valve assembly, exhalation	G-061526-00	Figure 9-13	1
		Section 9.25	5
Ventilator attachment kit (attaches ventilator to cart)	G-061849-00	Figure 9-5	27-29

Description	Part no.	Figure no.	Item no.
Ventilator breathing circuit	Contact your Nellcor Puritan Bennett representative for ordering information.	Figure 9-1	2
Ventilator breathing circuit, adult, reusable, without heated wire (for use as test circuit)	G-061208-00	Section 9.26	7
Washer, EX LK, M4 (Attaches ball bracket to cart)	--	Figure 9-5	26
Washer, EX LK, M6 (Attaches column to base)	--	Figure 9-5	5
Washer, EX LK, M6 (Attaches cylinder bracket to cart)		Figure 9-5	14
Washer, EX LK, M6 (Attaches ventilator to cart)		Figure 9-5	29
Washer, EX LK, M6 (Attaches ventilator to cart)		Figure 9-4	11
Washer, fiber (Attaches LCD panel)	G-061719-00	Figure 9-7	24
Washer, flat, M3 (Attaches cable tie that retains main ventilator head harness)	G-060998-00	Figure 9-8	49
Washer, flat, M3 (Attaches fan to fan guard)		Figure 9-19	14
Washer, flat, M3 (Attaches power supply fan to bracket)		Figure 9-20	24
Washer, flat, M4 (Attaches ball bracket to cart)	G-061028-00	Figure 9-5	25
Washer, flat, M4 (Attaches collector vial bracket to plate)		Figure 9-6	8
Washer, flat, M4 (Attaches collector vial support bracket to cart)		Figure 9-5	19
Washer, flat, M4 (Attaches exhalation solenoid)		Figure 9-17	14
Washer, flat, M4 (Attaches line filter ground wire)		Figure 9-20	42
Washer, flat, M4 (Attaches power input terminal ground wire)		Figure 9-20	55
Washer, flat, M5 (Attaches exhalation assembly cover)	G-060999-00	Figure 9-13	23
Washer, flat, M5 (Attaches ground wire)		Figure 9-4	6
Washer, flat, M5 (Attaches Hudson support bracket to cart interface bracket)		Figure 9-5	41
Washer, flat, M5 (Attaches humidifier support bracket to cart)		Figure 9-5	34
Washer, flat, M5 (Attaches motor/encoder)		Figure 9-18	15
Washer, flat, M5 (Attaches piston/cylinder to cabinet)		Figure 9-18	10
Washer, flat, M5 (Attaches plate to bracket)		Figure 9-6	4
Washer, flat, M5 (Attaches ventilator to shelf mount)		Figure 9-6	11
Washer, flat, M6 (Attaches assembled ventilator/mount to shelf)	G-061649-00	Figure 9-6	14
Washer, flat, M6 (Attaches column to base)		Figure 9-5	4
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